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NAME OF AUTHOR/*NOM DE L'AUTEUR* Terrance Richard Limbeck

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NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* B K SINHA

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DATED/*DATÉ* Nov 13/75 SIGNED/*SIGNÉ* T R Limbeck

PERMANENT ADDRESS/*RÉSIDENCE FIXÉ* 991 Cottonwood Ave
Sherwood Park
Alberta

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ANXIETY, LOCUS OF CONTROL AND AUTONOMIC PERCEPTION AS FACTORS IN THE CONTROL OF DIASTOLIC BLOOD PRESSURE BY FEEDBACK AND REINFORCEMENT

by

TERRANCE RICHARD UMBACH (C)

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Anxiety, Locus of Control and Autonomic Perception as Factors in the Control of Diastolic Blood Pressure by Feedback and Reinforcement" submitted by Terrance Richard Umbach in partial fulfilment of the requirements for the degree of Master of Science:

R K Surbi
.....
Supervisor

T. J. Hutchinson
.....

Charles Beech
.....

Date..... Nov 7 1972

ABSTRACT

An experiment was performed to determine if contingent reinforcement for diastolic blood pressure decreases caused a greater decrease in blood pressure than did noncontingent (random) reinforcement. Additionally, the relationship between anxiety, locus of control, autonomic perception and the ability to learn blood pressure control was investigated.

The results showed there were no significant differences between groups receiving contingent and noncontingent reinforcement. Reasons for the failure of the group receiving contingent reinforcement to decrease their blood pressure may have been that the feedback received by the subjects was confusing to them, they were not sufficiently motivated by the reinforcement they received, they found the experimental situation stressful and they did not receive enough practice to master such a difficult task. These results cast doubt on the claims made by several previous studies that significant differences between groups reinforced for increases in blood pressure and groups reinforced for decreases in blood pressure indicate that the subjects were able to learn control of their blood pressure by biofeedback procedures.

Additionally, the results showed no relationships between anxiety, locus of control, autonomic perception and the ability to learn control of blood pressure. This was likely due to the failure of any of the subjects to learn the task because of its difficulty and their lack of motivation.

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CHAPTER I

INTRODUCTION

High Blood Pressure as a Health Problem

High blood pressure is a serious health problem. Studies have estimated that it affects between 10% to 30% of the North American population. In the United States, Wilber and his associates (1972) screened 6,012 individuals, 28.5% of whom he classified as hypertensives. In Canada, in a study using two Edmonton shopping centres in screening for hypertension, Silverberg, Smith, Juchli and Van Dorsser (1974) found 12.1% of the sample population to be hypertensive.

Elevated blood pressure significantly increases the risk of cardiovascular diseases. In the Framingham studies (Kannel, Dawbar, Kagan, Revotskie & Stokes, 1961; Kannel, Schwartz & McNamara, 1969) risk of coronary heart disease was related to the antecedent level of both systolic and diastolic blood pressure. Risk was not related solely to "hypertensive" as compared to "normotensive", but was proportional to the level of blood pressure--even at non-hypertensive pressures. Cardiovascular and cerebrovascular diseases are the main cause of death in North America. In Canada cardiovascular-renal diseases, diseases of the heart and cerebrovascular diseases accounted for 62.2% of the total deaths in 1972 (Statistics Canada, 1974).

Approximately 90% of the individuals with hypertension are classified as having "essential" hypertension, which by definition means that no etiology is known (Laraugh, 1965; Guyton, 1966). A proportion of these undoubtedly have something organically wrong with them that has not been found (Folkow & Neil, 1971), but others likely develop

essential hypertension because they react to the stresses in their environment with increases in blood pressure (Gutmann & Benson, 1971). Although not as harmful as fixed hypertension, these labile blood pressure elevations may contribute to risk of acquiring more serious problems (Kannel, Schwartz & McNamara, 1969).

Medical Treatment of High Blood Pressure

Although hypertension can be treated by the use of drugs, there are often harmful side effects resulting from such usage. All drugs are potentially hazardous to some extent and unless prescribed and administered with caution, the patient may be seriously injured. Many people are admitted to hospitals and even die because of serious reactions to drugs (Martin, 1971).

Drugs used in the treatment of hypertension such as reserpine, methyldopa and guanethidine have numerous side effects. They may cause sedation and drowsiness, nightmares, bradycardia, diarrhoea, nasal congestion, blurred vision and diminished intellectual capacity (Meyer, 1966). Additionally, although there is no doubt that blood pressure can, in most cases, be decreased by drugs, some researchers feel that the value of antihypertensive drug treatment has not been established for the general hypertensive population or for those with essential hypertension (Chasis, 1974).

Biofeedback as a Treatment for High Blood Pressure

Recently biofeedback has been put forth as a treatment technique for various physiological dysfunctions including tension headaches (Budzynsky, 1970), hypertension (Schwartz & Shapiro, 1973), and

atrial fibrillation (Bleecker & Engel, 1973). Biofeedback consists of providing an individual with feedback for a specific physiological function. The method permits modification of functions once considered involuntary and automatic. Although these functions were, until recently, considered uncontrollable by the individual, it has long been recognized that they are under the influence of the individual's environment (Gutmann & Benson, 1971; Wolpe, 1958).

Biofeedback would allow the individual to gain control over the function in question. First, control would be learned in the laboratory under actual biofeedback conditions, then in the laboratory without biofeedback, and finally, in the individual's actual environment. Such a technique would appear to be especially useful in essential hypertension where the environment seems to be a large factor in disease etiology (Gutmann & Benson, 1971).

The operant conditioning of blood pressure using biofeedback techniques was first done using animals as Ss. Miller (1969) successfully trained rats to both increase and decrease their blood pressure using escape from painful shock or electrical stimulation of rewarding areas in the brain as reinforcements to shape the desired response. Harris, Gillian, Findley and Brady (1973) used food and shock avoidance to shape blood pressure increases in baboons. These animals were able to produce large blood pressure changes which they maintained over the 12 hour daily sessions.

On human Ss the first studies (Shapiro, Tursky, Gershon & Stern, 1969; Shapiro, Tursky & Schwartz, 1970a, 1970b) used normotensive

college students in attempts to determine if they could learn to increase or decrease their systolic blood pressure. Results comparing increase groups with decrease groups seemed to indicate that they were able to do so. Similarly, diastolic blood pressure appeared to be controllable (Shapiro, Schwartz & Tursky, 1972).

Although these studies produced statistically significant results, they were not clinically significant. The difference between the blood pressure in the increase groups and the decrease groups was very small. As well, this procedure did not show that biofeedback is useful in training subjects to decrease their blood pressure--only that there were differences between increase and decrease groups. The significance of the results may have been due to the success of the increase group while the decrease group's reduction could have simply been the result of adaptation to the experimental situation. If blood pressure control can only be exerted in the upward direction, it is of little use in the treatment of hypertension.

After the apparent success of these studies using normotensive Ss, several studies were done on patients with essential hypertension. Benson, Shapiro, Tursky and Schwartz (1971) were able to condition decreases from 16 to 34 mm Hg in systolic blood pressure in six out of seven patients with essential hypertension. Krist and Engel (1975) trained five patients with essential hypertension to take their own blood pressure at home and to raise or lower systolic blood pressure both with and without biofeedback. All five patients learned to increase and decrease their blood pressure and follow up tests one and

three months later showed they retained control. Home systolic blood pressure fell 18 to 8 mm Hg and the patients were able to decrease home blood pressure from 141 mm Hg average to 125 mm Hg average using the techniques they learned in the laboratory.

Although these results are impressive, they do not prove the effectiveness of biofeedback in the treatment of hypertension. These results could be due to the positive expectations of the patients or some other aspect of the experimental situation. Brady, Luborsky and Kron (1974) found that hypertensive patients who received Metronome Conditioning (which consisted of taped instructions to "relax" and "let go" paced with the rhythmic beats of an auditory metronome set at 60 beats per minute) showed a significant blood pressure drop when treatment was instituted. Blood pressures rose again when Metronome Conditioning was discontinued. Benson, Rosner, Marzetta and Klemchuk (1974) found a significant difference in systolic and diastolic blood pressure in borderline hypertensives before and after learning transcendental meditation. Both these studies took blood pressure measurements at times other than when the Ss were practicing. It appears that any technique that decreases sympathetic nervous system activity may cause blood pressure reduction.

In order to demonstrate that biofeedback is clinically useful in the treatment of hypertension, it is necessary to show that blood pressure reductions are significantly different from those produced by habituation, adaptation or being exposed to a relaxing environment. This can be done by comparing the results of a group receiving feed-

back contingent on their blood pressure with one receiving random, but similar, feedback. Only one study (Shapiro, Tursky & Schwartz, 1970a) attempted to do this. They used normal Ss and found no significant differences between the group reinforced for decreasing blood pressure and the group receiving random feedback. However, in this study only 25 trials were used. The present study will compare the results of two groups, one reinforced for decreasing blood pressure and one receiving random feedback for 35 trials. The extra 10 trials may provide Ss receiving contingent feedback with enough practice to decrease their blood pressure significantly when compared with Ss receiving random feedback. This will be one of the hypotheses tested in this experiment.

These studies involving the operant conditioning of blood pressure in humans used a method developed by Shapiro, Tursky, Gershon and Stern (1969) which provides information to Ss about relative changes in blood pressure on each heart cycle. This method uses a conventional blood pressure cuff with a microphone mounted in it. Either diastolic or systolic blood pressure can be conditioned. The pressure in the cuff is kept constant at whichever blood pressure is being conditioned. Diastolic blood pressure was used in the present experiment because the lower cuff pressure required was less likely to cause Ss discomfort. Each trial was 50 heart beats long. This was determined by the use of an electrocardiogram. Respiration rate was taken to make certain Ss did not change their blood pressure by varying their breathing pattern. An electromyogram was used to determine if Ss were attempting to manipulate the apparatus by muscular movements.

Individual Differences in the Ability to Learn Blood Pressure Control

Studies which involved blood pressure conditioning showed the effects of individual differences (Shapiro, Schwartz & Tursky, 1972; Shapiro, Tursky, Gershon & Stern, 1969; Shapiro, Tursky & Schwartz, 1970a, 1970b). Not all Ss conditioned equally well. None of these studies attempted to determine what personality factors might be involved in these differences.

Anxiety and Blood Pressure

General relationship of blood pressure to anxiety. Anxiety is one personality trait that might be useful in accounting for the individual differences in ability to control blood pressure. According to Wolpe (1958) anxiety is the "autonomic response pattern or patterns that are characteristically part of the organism's response to noxious stimulation." A noxious stimulus is "one that causes tissue disturbance of a kind that leads to avoidance responses." The autonomic response is generally a widespread discharge of the autonomic nervous system, predominantly the sympathetic division.

One of the physiological responses of man and animals to a noxious stimulus such as an electric shock is a rise in arterial blood pressure (Pickering, 1968; Katcher, Solomon, Turner, LoLordo, Overmier & Rescorla, 1969; Yehle, Dauth & Schneiderman, 1967). An increase in blood pressure would therefore be part of the physiological response of anxiety.

Additionally, Wolpe (1958) stated that a stimulus not previously able to cause an anxiety response may acquire the power to do so if it happens to be acting on the organism at the same time that anxiety is

evoked by another stimulus. Using a painful shock Yehle, Dauth and Schneiderman (1967) have classically conditioned blood pressure increases to a conditioned stimulus.

Further, Wolpe states that in turn the stimulus which was first paired with the unconditioned response then becomes a conditioned stimulus to anxiety and the anxiety it evokes may be conditioned to yet further stimuli so that in time, there are more anxiety responses to conditioned stimuli than to unconditioned stimuli. In this manner, situational stimuli such as storms, clouds, rejection or even more or less omnipresent aspects of the environment can be conditioned to evoke anxiety responses.

Studies using animals have demonstrated that blood pressure is amenable to this kind of conditioning. Forsyth (1968, 1969, 1971, 1972) subjected monkeys to avoidance conditioning schedules in which they were required to press a lever resetting a timer. If the timer was allowed to complete its cycle a noxious shock was delivered to the tail. This treatment resulted in significant increases in blood pressure to all the monkeys exposed to it, even though they learned the task and actually received few shocks.

Anderson and Brady (1973) used dogs in a similar conditioning situation and found not only that the dogs increased their blood pressure during conditioning, but that during a pre-avoidance interval, when the animals were placed in the apparatus and it was not turned on, there were increases in blood pressure. In these experiments blood pressure increases were related not only to the stress of avoiding

shocks, but to being exposed to the threatening environment.

That blood pressure rises can be caused by long-term omnipresent aspects of the environment was shown by Kasl and Cobb (1970), who found that individuals who had been stably employed had higher blood pressure levels during anticipation of loss of their job due to a permanent plant shutdown and during unemployment or probationary re-employment than they did later when they were stabilized on new jobs.

Individual differences in anxiety levels and autonomic reactivity. According to Wolpe (1958) individual differences in anxiety level are due to individual differences in general emotional reactivity. In a given situation a highly reactive individual would have a greater intensity of conditionable anxiety evoked in him than an individual whose reactivity was low. Mandler, Mandler and Uviller (1958) constructed a test called the Autonomic Perception Questionnaire (APQ) with which they attempted to determine the relation between autonomic responses and the perception of such activity. They found that individuals who reported high autonomic activity also showed high autonomic reactivity when under stress, while individuals reporting low autonomic reactivity showed low reactivity under stress. Further, individuals who reported high activity tended to overestimate their reactivity, while those reporting low autonomic reactivity tended to underestimate theirs. Mandler, Mandler and Uviller (1958) found a positive correlation between reported level of autonomic reactivity and scores on the Taylor Manifest Anxiety Scale (Taylor, 1953). Thus, highly anxious individuals were not only highly reactive to stress, but were overly

aware of their reactivity, whereas low anxiety individuals were unresponsive to stress and less aware of their reactivity. It may be that middle anxiety scorers are moderately reactive to stress and accurately perceive their responses.

Individual differences in autonomic conditionability. If high anxiety individuals are highly reactive and very sensitive to their activity they would receive a great deal of internal feedback about their physiological activity. They may receive so much that they have difficulty discriminating between the activity of one function and the others, and so have difficulty learning to control a physiological function using biofeedback where they must associate the external biofeedback with their internal feedback. On the other hand, low anxiety individuals may receive so little feedback that they will not do well either. However, middle anxiety individuals should receive enough internal feedback that they will be able to associate the correct cues with biofeedback, but not so much that they will be overwhelmed.

McFarland and Coombs (1974), using the Taylor Manifest Anxiety Scale (Taylor, 1953), found that middle anxiety scorers were able to control their heart rates significantly better than were high and low anxiety scorers. Bergman and Johnson (1971) using the APQ, had Ss attempt to increase or decrease their heart rates without externalized feedback. They found that the group with middle APQ scores were better able to control heart rate in both directions than were the low and high APQ groups. From this it would be reasonable to predict that middle anxiety and middle APQ scorers would do better at learning to

control their blood pressure than would high and low scorers. This will be one of the hypotheses tested in this experiment.

Internal vs. External Locus of Control and Blood Pressure

Another concept that might be useful in predicting success using biofeedback is that of internal vs. external locus of control of reinforcement (Rotter, 1966; Rotter, 1975). A high internal score indicates the individual feels he has a large degree of control over the rewards he receives from his environment, while a high external score indicates he feels he has little control.

An individual's total environment consists not only of objects outside of himself, but as well, his own internal bodily feelings. A general expectancy as to ability to influence rewards will likely extend to the internal environment as well as the external. Someone who cannot control himself will unlikely feel that he can control his external environment. Therefore, it would be expected that individuals with high internal scores would be better able to use their own internal feedback to control their physiological functions. In this case they should also be better at associating these internal cues with biofeedback and so do better at learning to control their blood pressure. This is one of the hypotheses tested in this experiment.

Several studies have shown that internal locus of control individuals are better able to exert control using biofeedback. Johnson and Meyer (1974) used Nowicki and Strickland's (1973) alternative to Rotter's (1966) I-E Scale and found that individuals with an internal locus of control were better able to use biofeedback to increase their alpha

activity than external scorers. Wagner, Bourgeois, Levenson and Denton (1974) used Levenson's (1973) scale which attempts to measure three aspects of locus of control: Expectance of control by self (I scale); powerful others (P scale); and chance (C scale). Individuals more successful at using biofeedback to control GSR had significantly higher I scale scores.

Usefulness of Personality Tests in Biofeedback Treatment of Hypertension

If these tests are related to the ability to learn blood pressure control they would be useful in predicting which hypertension patients are likely to benefit the most from biofeedback training. Because a great deal of time, effort and equipment is required for such training, an individual with little chance of success might be better off receiving some other sort of treatment.

Stroebel and Glueck (1973) derived the Placebo-Active Therapeutic Index (PATI) which they found useful in estimating the current and long term effectiveness of alpha brain wave treatment. This index consisted of two scales: The degree of voluntary control actually achieved by the S during biofeedback conditioning; and, the degree of expectancy which was the enthusiasm and the confidence the S had in the treatment. Individuals with both good voluntary control and a high degree of expectancy were found to perform well in the laboratory setting and to continue practicing after training had ended. Although this would be useful in predicting long term success of treatment, it does so only after the S has taken biofeedback training for some time. This is because the ability to achieve voluntary control using biofeedback must

first be determined. If the tests used in the present study are able to predict this degree of voluntary control then the PATI could be computed before training began and used to predict the likelihood of success.

Additionally, if a relationship between ability to control blood pressure and anxiety were found, treatment of both blood pressure and anxiety might prove more effective than either one alone. An individual who is highly anxious and so unlikely to succeed at learning control of blood pressure, and as well is sensitive to the side effects of drug treatment, could first receive treatment for anxiety, and later undergo blood pressure conditioning.

Purposes and Hypotheses

The primary purpose of this study was to determine if blood pressure biofeedback training might be useful in the clinical treatment of hypertension. A related purpose was to determine whether objective tests of personality could predict success in the ability to control blood pressure in a paradigm in which Ss were encouraged to decrease their blood pressure. The following hypotheses were tested in this research:

1. Ss receiving contingent blood pressure feedback will decrease their blood pressure more than Ss receiving random feedback (Page 6).

2. Ss receiving contingent blood pressure feedback who obtain middle scores on the IPAT Anxiety Questionnaire will decrease their blood pressure more than contingent Ss with high and low IPAT Anxiety Questionnaire scores (Pages 10 and 11).

3. Ss receiving contingent blood pressure feedback who obtain

middle scores on the APQ will decrease their blood pressure more than contingent Ss with high and low APQ scores (Pages 10 and 11).

4. Ss receiving contingent blood pressure feedback who obtain high internal scores on the IE Scale will decrease their blood pressure more than contingent Ss with high external scores (Page 11).

CHAPTER II

METHOD

Design

The main part of this study used a trend analysis design in which an organismic and a treatment factor were investigated. The organismic factor of interest was anxiety (A) with three levels: High, middle and low. The treatment factor (G) involved in the experiment was the type of feedback the S received. There were two levels of this factor, one being contingent feedback and the other random feedback. The stage factor (T) consisted of seven trial blocks of five trials each. The independent variables were blood pressure, heart rate, respiration rate and EMG activity.

The secondary part of the study used a correlation design. The independent variables were APQ score, IE scale score, and feedback group. The dependent variables were blood pressure, heart rate, respiration rate and EMG activity.

Subjects

Ss consisted of 30 University of Alberta students enrolled in a first year Psychology course. They were chosen from a class of 241 students, on the basis of scores obtained during mass testing, when they were requested to fill out the IPAT Anxiety Scale (Cattell & Scheier, 1963), Rotter's (1966) I-E Scale and an approximation of Mandler, Mandler and Uviller's (1958) Autonomic Perception Questionnaire.

Prospective Ss were chosen in accordance with scores obtained on the IPAT Anxiety Scale. High, middle and low anxiety groups were

required, with 10 Ss in each group. In order to obtain these groups the experimenter (E) selected those Ss with the extreme high scores and the extreme low scores for the high and low anxiety groups. Ss with scores around the overall mean were selected for the middle anxiety group. The high anxiety group consisted of Ss who scored between 42 and 56, the middle group between 31 and 34, and the low group between 13 and 21. E contacted these individuals by telephone. Those who expressed an interest in participating were asked if they had any cardiac, blood pressure, respiratory, hearing, sight, or psychological problems and how they would rate their present state of health. Individuals with no problems were requested to participate in the experiment as part of their course requirements, or, if they had already fulfilled these, for monetary payment. If they required one hour of experimental credit they were offered $2.50 and if they required no experimental credit they were offered $5.00.

If this was acceptable an appointment was made for the running of the experiment. Ss in each anxiety group were assigned to random or contingent conditions alternately when they agreed to participate. For example, the first middle anxiety S was assigned to the random condition, the second to the contingent condition, the third to the random, and so on.

Apparatus

A number of related instruments were used to measure blood pressure and provide S with biofeedback. Figure 1 gives a block diagram of this system.

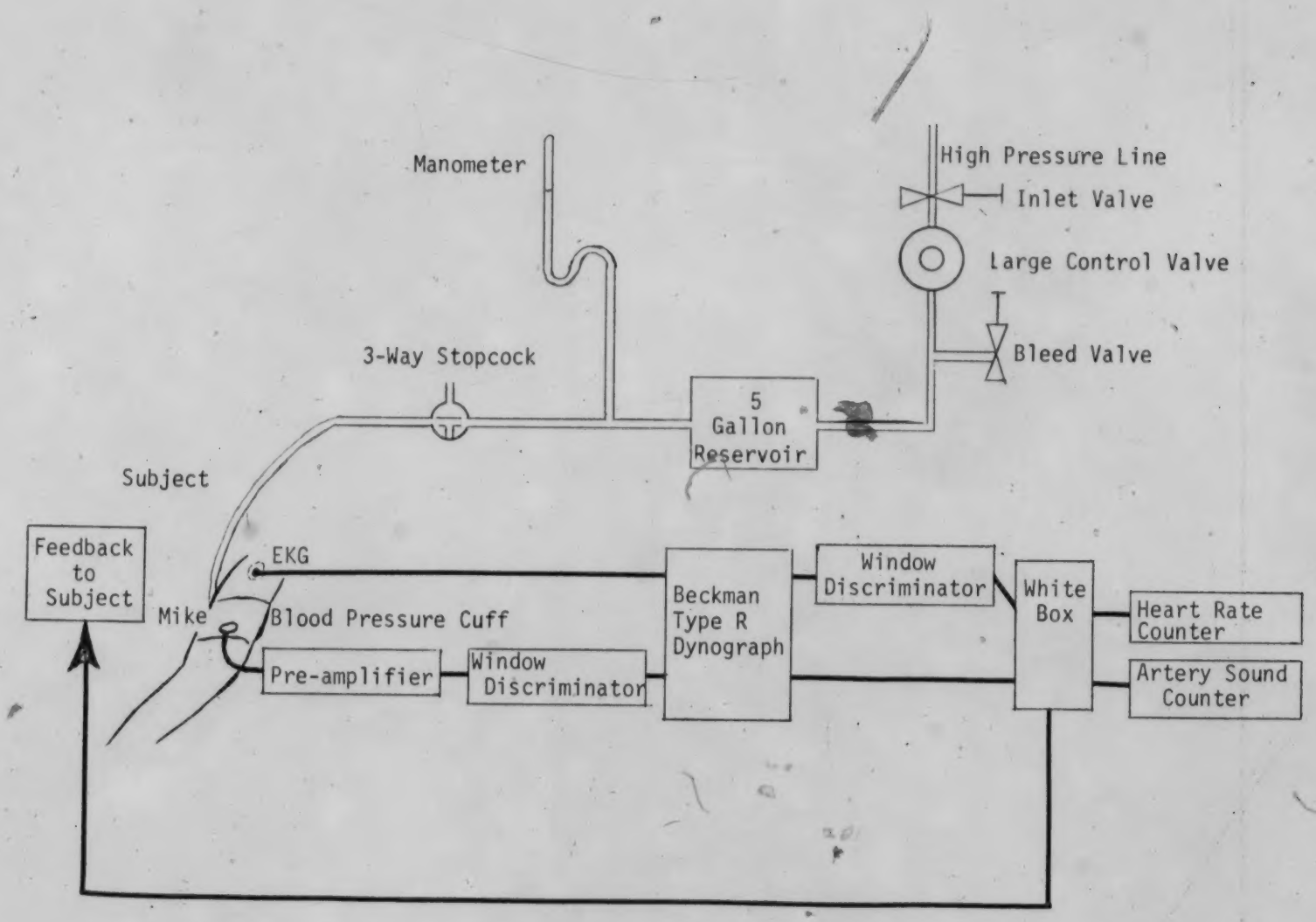

Figure 1: Block diagram of blood pressure biofeedback system.

A standard blood pressure cuff (Velcro) was used to apply pressure to the brachial artery. It was connected to a compressed air source in such a way that it could be maintained at a constant pressure as well as used in the conventional manner.

For constant pressure usage, air from the high pressure main line was first roughly controlled by a Swagelok gate valve. Next in line was a large very sensitive valve designed for delivering puffs of air in eyeblink conditioning. Next was another Swagelok gate valve which served as a bleed to the outer air. From there air was fed into a five gallon reservoir. From the reservoir, plastic tubing led to a three-way stopcock and a standard blood pressure manometer. One of the outlets on the stopcock was connected with plastic tubing to the blood pressure cuff and the other was left open to the atmosphere.

Operation involved opening the first valve to allow air to enter the system, then opening the bleed valve to allow a moderate amount of air to escape. The large valve was then adjusted, using the manometer, to set the desired pressure level in the reservoir. For a trial the stopcock was opened to allow air to inflate the blood pressure cuff. At the end of the trial the stopcock was turned to close off the line from the reservoir and vent the air in the cuff.

For standard usage, the bleed valve was closed and the intake valves opened to increase pressure in the cuff to the desired level. Then these valves were closed and the bleed valve used to slowly deflate the cuff.

Artery sounds were picked up by a small microphone mounted in the

blood pressure cuff. This microphone was connected to an electrosphygmograph (Physiograph MK IV) which served as a preamplifier. The output from this was fed to a window discriminator (Model LVE 1755) which filtered and amplified the signal. The lower window level was used to cut out noise and set the criterion level of acceptance for artery sounds (this was done by using diastolic pressure plus 5 mm Hg pressure and setting the window at just below the level at which it picked up an artery sound for each heart beat). The activity of the window discriminator was monitored on a dual beam oscilloscope.

The output from the window discriminator was in the form of a single pulse for each time the window level was reached. The pulse was fed to a Beckman Type R Dynograph where it was recorded on one channel and then fed out the back to a pulse shaping, timed, and switched, monostable circuit (white box).

Beckman skin electrodes were attached to Ss' wrists using adhesive collars and electrode gel. These were connected directly to the Beckman Dynograph where the input was charted (this was the electrocardiogram--EKG), and from there to another window discriminator which was used to pick off the R wave of the EKG. This was monitored on another dual beam oscilloscope.

The output from this window discriminator was fed into the white box. Here it was used to open a time window 300 ms long. If, during this window an artery sound occurred, a pulse was delivered out of the white box to a counter (General Radio 1191)--the artery sound counter --and as well to the feedback stimuli (a red light-emitting-diode and

a buzzer). As well, the input from the EKG triggered another counter so that the number of heart beats were also counted.

In order to measure respiration rate a chest bellows was attached to S. It was connected to the pressure transducer on the electrosphygmograph which was connected directly to the Beckman, where it was recorded on another channel.

To record EMG activity, two Beckman skin electrodes were attached over the biceps of the left arm, one above and one below the blood pressure cuff. EMG activity was recorded directly on the Beckman.

For Ss who received random feedback the apparatus was the same as that described above except that the feedback they received was generated by a separate circuit.

To provide non-contingent Ss with feedback, a Ledox rotary selector was used. Nine channels were used and a different percent of feedback was set on each channel (one each of 10, 20, 30, 40, 50, 60, 70, 80, and 90%). Any channel could be used for a given trial. Two Hunter interval timers triggered the rotary selector. They were adjusted so as to give S feedback at the same rate as his heart beat.

The difference between the feedback received by the random and contingent Ss was that for contingent Ss, feedback was synchronized with Ss' heart beat and depended upon whether or not S produced an artery sound, while for the random Ss the feedback was not synchronized with heart beat (although delivered at the same rate as heart rate) and it was independent of whether S produced an artery sound or not.

A Kodak Carousel AV-900 projector was used to project pictures on a

screen located in front of S. Pictures were all of scenery with blank slides with a sum of money reflecting how much S had earned every 10 slides. Slides were interspaced with cardboard so that the pictures could be projected for a short time and then the light from the projector shut off.

An intercom was used to communicate with S and a tape recorder was used to deliver instructions.

Procedure

The data were collected in Room P-326 in the Psychology Wing of the Biological Sciences Building, University of Alberta, Edmonton, Alberta. A 7 x 7 electrically and acoustically shielded chamber was used to isolate S from the apparatus.

S was seated in a comfortable chair facing the feedback light and projector screen which were mounted on the opposite wall of the experimental chamber room. The blood pressure cuff was attached to the upper left arm. Skin electrodes were attached to each forearm, above and below the left biceps and to the left earlobe. A bellows was fastened around S's waist. A male E ran male Ss and a female E ran female Ss.

After S was connected, the following taped instructions were delivered:

> *This research is concerned with the ability of individuals to control certain physiological responses usually considered involuntary. However, control can often be achieved when information or feedback is given. The feedback you will receive will be the flashing of the*

red light which is located in front of you. Your task will be to attempt to control the physiological response by making the light flash on and the buzzer buzz as often as you can. The green light, above the red, will indicate a trial period. You are to attempt to make the red light flash only during a trial period, when the green light is on. Please do not move about or tense your muscles during the trial sessions and keep your breathing as regular as possible. The experiment will begin by the cuff on your arm being inflated and slowly deflated three times. Following this the cuff will be inflated to a low pressure and held there for about one minute. There will be five such trials, with a rest period between each trial. During these trials the green light will not be on and you are not required to try and make the red light flash. After these five trials, the cuff will again be inflated to a low pressure for 35 trials. Again, each trial will last about one minute and there will be rest periods in between. During these trials the green light will be turned on to indicate to you that you are to attempt to make the red light flash. Remember, you are to do so without moving, tensing your muscles or changing your breathing. You will be informed when this phase is to begin. Please do not hesitate to inform me if you feel any discomfort or if anything appears to be wrong. For example, if any of the apparatus comes loose. You can speak to me through the microphone to your right. Any questions?

If there were no questions, S was left and the door closed. The blood pressure cuff was inflated to 140 mm Hg and then deflated at 2 mm Hg per heart beat to obtain systolic and diastolic blood pressure.

This was done three times with a two-minute rest between readings.

After a three minute rest interval, the cuff was inflated to the last diastolic pressure obtained and held there for 50 heart beats. If between 15 to 36 artery sounds occurred, this pressure was defined as median diastolic (Tursky, Shapiro & Schwartz, 1972) and used on the next trial. If between 37-48 artery sounds occurred, the cuff pressure was decreased by 2 mm Hg. If 49-50 artery sounds occurred, it was decreased by 4 mm Hg. If 3-14 sounds occurred the cuff pressure was increased by 2 mm Hg and if 1-2 occurred it was increased by 4 mm Hg.

Five preliminary trials (using this procedure) were run to arrive at the median diastolic blood pressure. This was the pressure used to begin the trials when feedback was given. After these five trials, taped instructions for the conditioning part of the experiment were given as follows:

> *Now you will be receiving feedback about the response you are to attempt to control. Your task is to make the red light flash and the buzzer sound as often as you can while the green light is on. On each trial you will first feel the cuff inflate and then the green light will go on. It is important that you minimize your movements; do not tense your muscles and keep your breathing as regular as you can. You will be paid in accordance with the number of times you are able to make the light flash. Every certain number of times the light flashes, a picture will be projected on the screen in front of you. These pictures are all of scenery. Every few pictures, a sum of money will be projected indicating how much money you have earned so far. Any questions?*

If there were no questions, the cuff was inflated to the median diastolic blood pressure (the last pressure used in the previous trials) and maintained there for 50 heart beats. During the trial the green light was turned on and feedback was given. Contingent Ss received feedback in the form of the red light flashing and the buzzer sounding for each artery sound. Noncontingent Ss received "feedback" from the random generator. The percentage of feedback random Ss received for a given trial was selected by using a table of random numbers.

During the entire experiment the EKG, respiration and EMG were recorded on the Beckman. The EKG was used to provide Ss' heart rate. Respiration rate was arrived at by counting the number of cycles that occurred during each trial. An estimate of muscle activity was derived by counting the bursts of EMG activity that occurred during the entire experiment.

After the 35 trials, Ss were unhooked, led from the chamber and requested to fill out the APQ and a questionnaire (Appendix A). After completing the questionnaires, Ss were asked if there were any questions. If Ss were interested E explained to them what functions he was trying to control and how the apparatus worked. Before leaving the Ss were requested not to reveal to anyone the nature of the experiment.

CHAPTER III

RESULTS

Three main types of data were obtained with respect to blood pressure, heart rate and respiration rate. These are considered separately, beginning with blood pressure. This is followed by presentation of additional data of interest consisting of correlations between the three personality measures used in the study and results of the post-experimental questionnaire. All ANOVA tables for blood pressure, heart rate, and respiration rate are found in Appendices B, C, and D, respectively. Correlation coefficients are shown in Appendix E.

Blood Pressure

Figures 2, 3, 4, 5, and 6 show the mean diastolic blood pressure for the preliminary and conditioning parts of the experiment. The 35 conditioning trials were grouped in blocks of five trials for graphic presentation and analysis.

Before conditioning began five preliminary trials, using the constant cuff pressure system, were run to arrive at Ss' diastolic blood pressure. Because three or four trials were sometimes required to track an S's blood pressure level, the last one taken in the series of five was used as the measure of preliminary blood pressure. Table 1 shows these blood pressures for the six experimental groups.

In order to determine if there were differences in preliminary blood pressures between groups a two factor ANOVA for the group factor (G) and the anxiety factor (A) was done. None of the F ratios were significant,

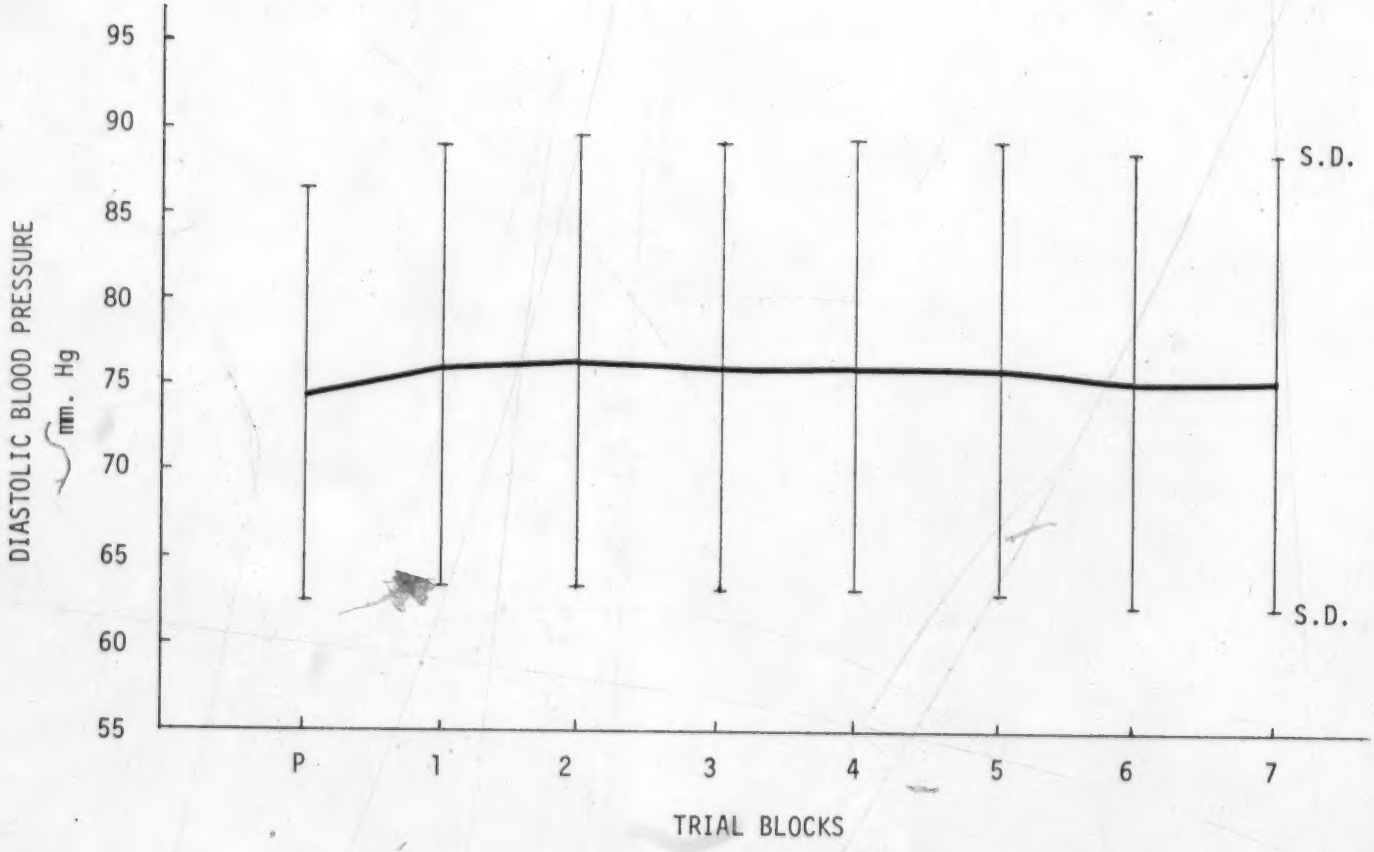

Figure 2: Mean diastolic blood pressure for all subjects, in blocks of five trials, for the 35 conditioning trials. The preliminary trial (P) consisted of the last trial before conditioning began. S.D. represents one standard deviation for the trial blocks.

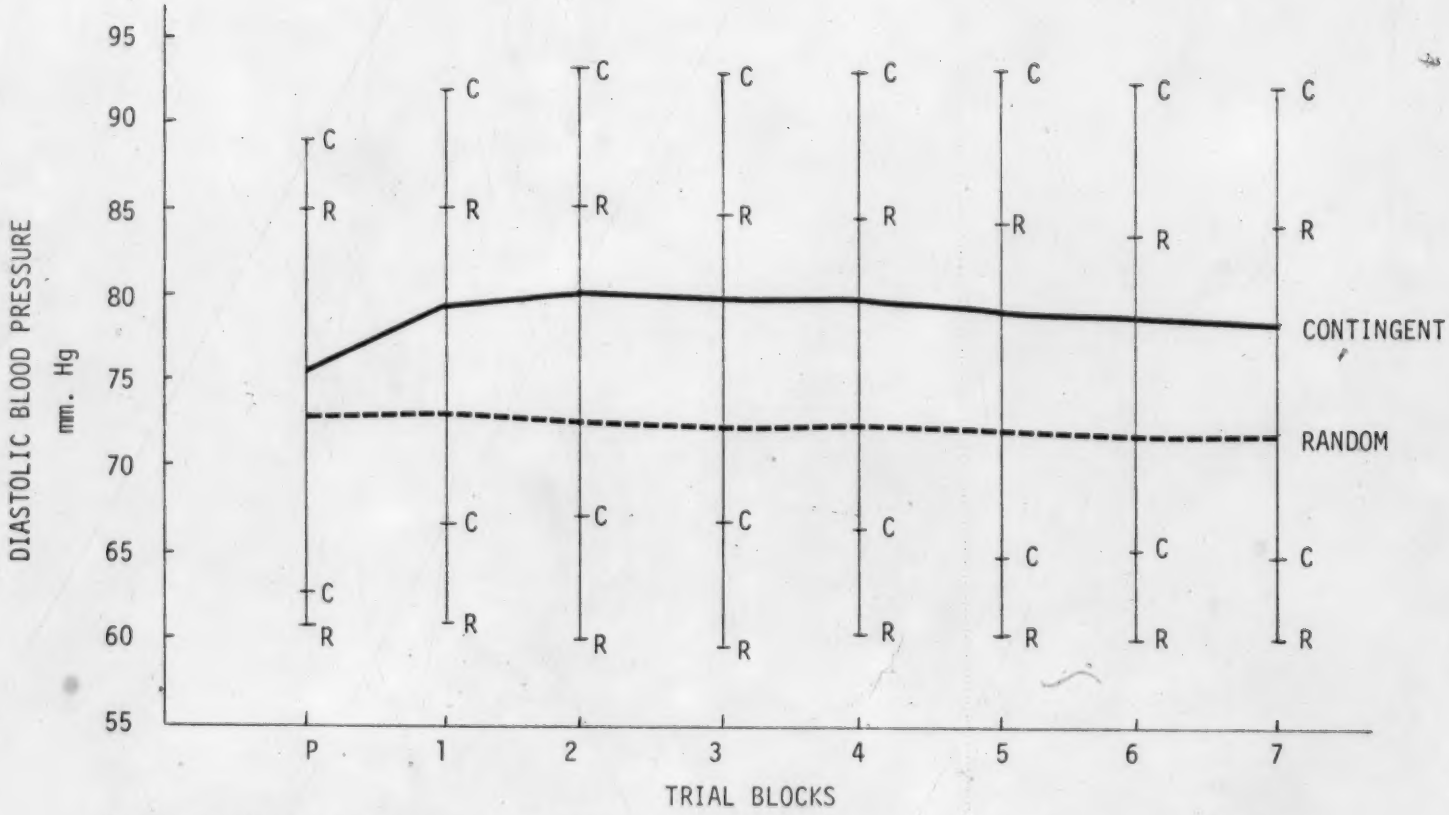

Figure 3: Mean diastolic blood pressure for the random and contingent groups, in five trial blocks, for the 35 conditioning trials. The preliminary trial (P) consisted of the last trial before conditioning began. R and C represent one standard deviation for the random and contingent groups respectively.

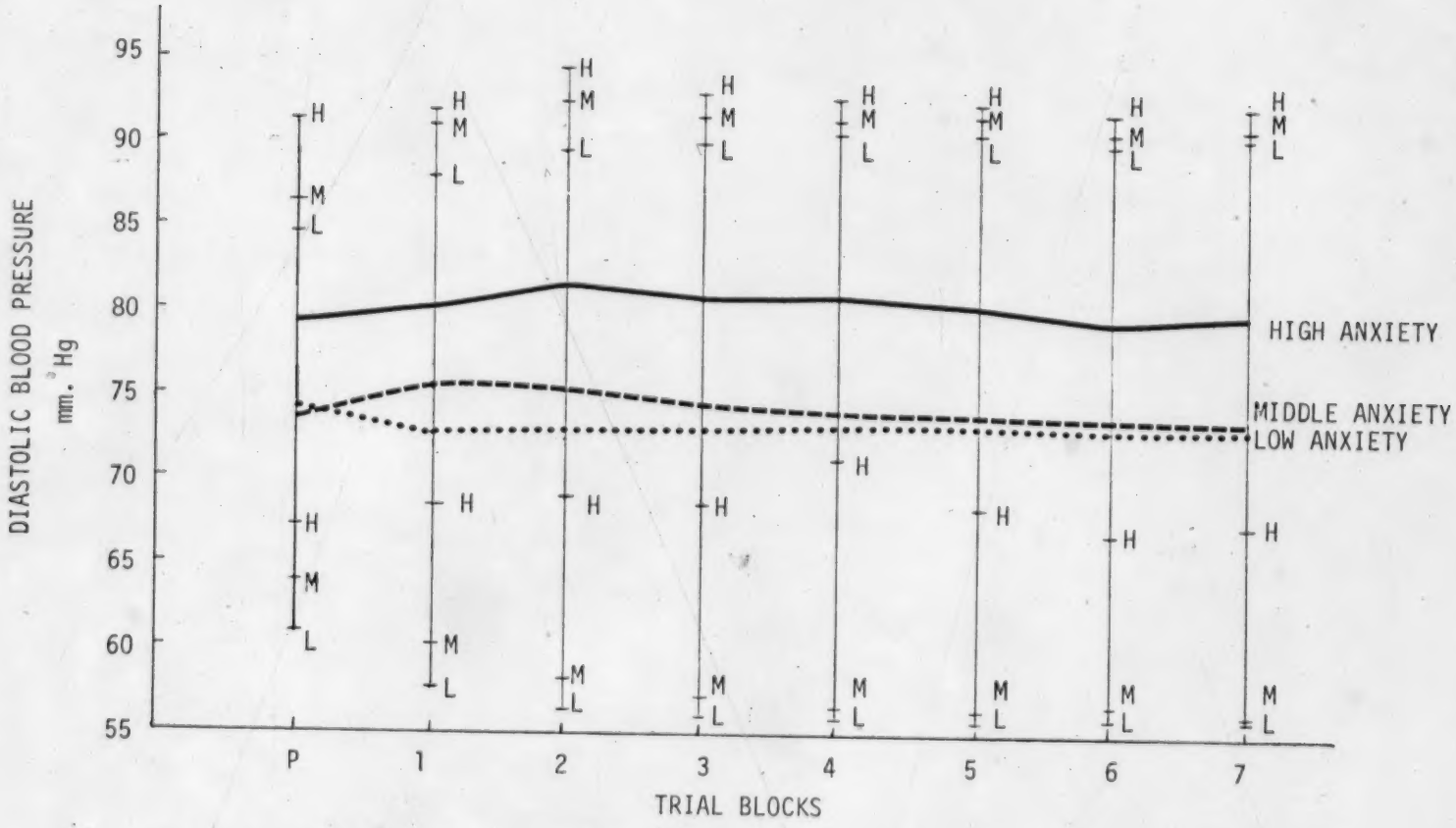

Figure 4: Mean diastolic blood pressure for high, middle and low anxiety groups for all subjects, in five trial blocks, for the 35 conditioning trials. The preliminary trial (P) consisted of the last trial before conditioning began. H, M and L represent one standard deviation for the high, middle and low anxiety groups respectively.

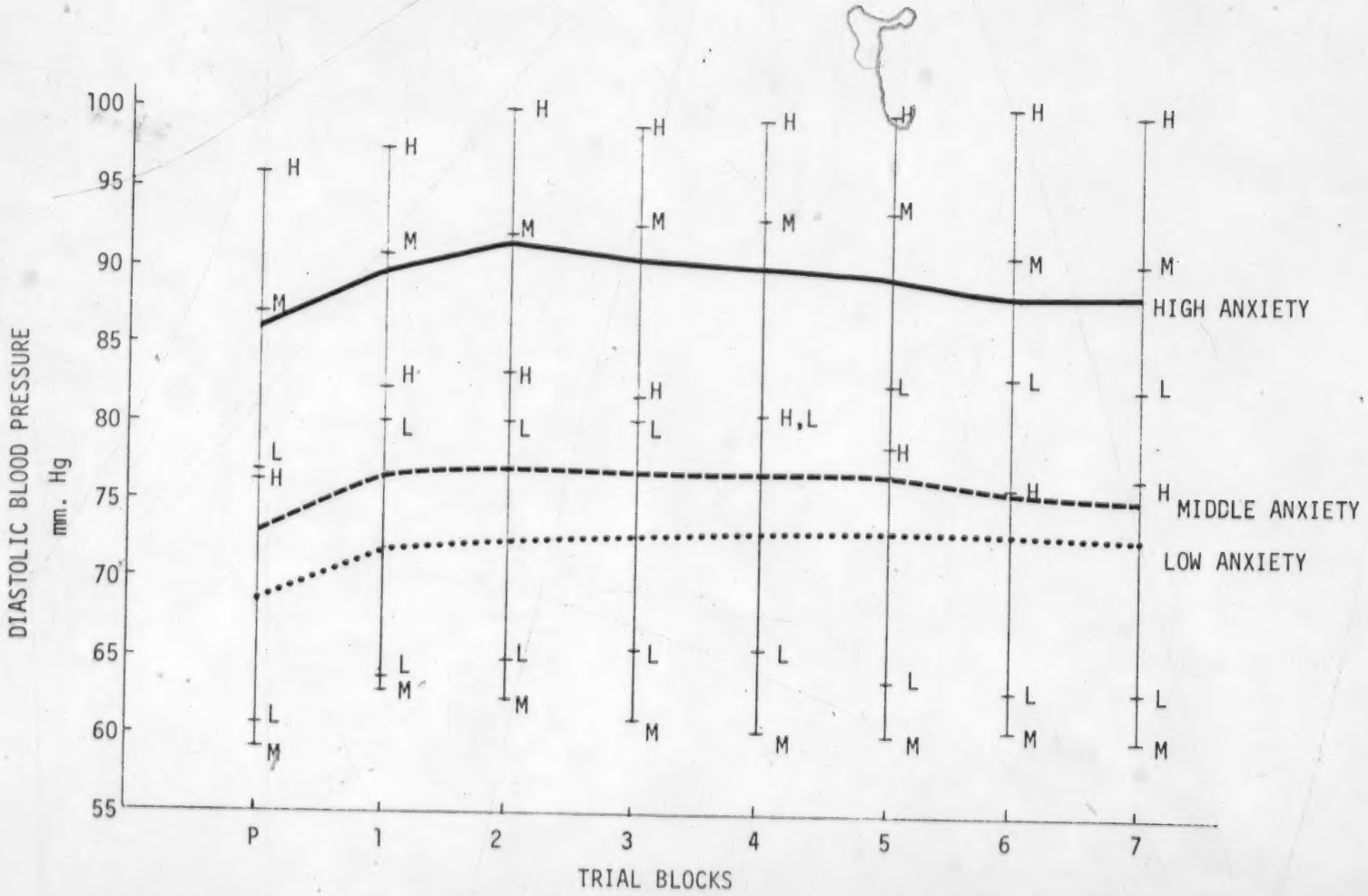

Figure 5: Mean diastolic blood pressure for the high, middle and low anxiety contingent groups, in blocks of five trials, for the 35 conditioning trials. The preliminary trials (P) consisted of the last trial before conditioning began. H, M, and L represent one standard deviation for the high, middle, and low anxiety groups respectively.

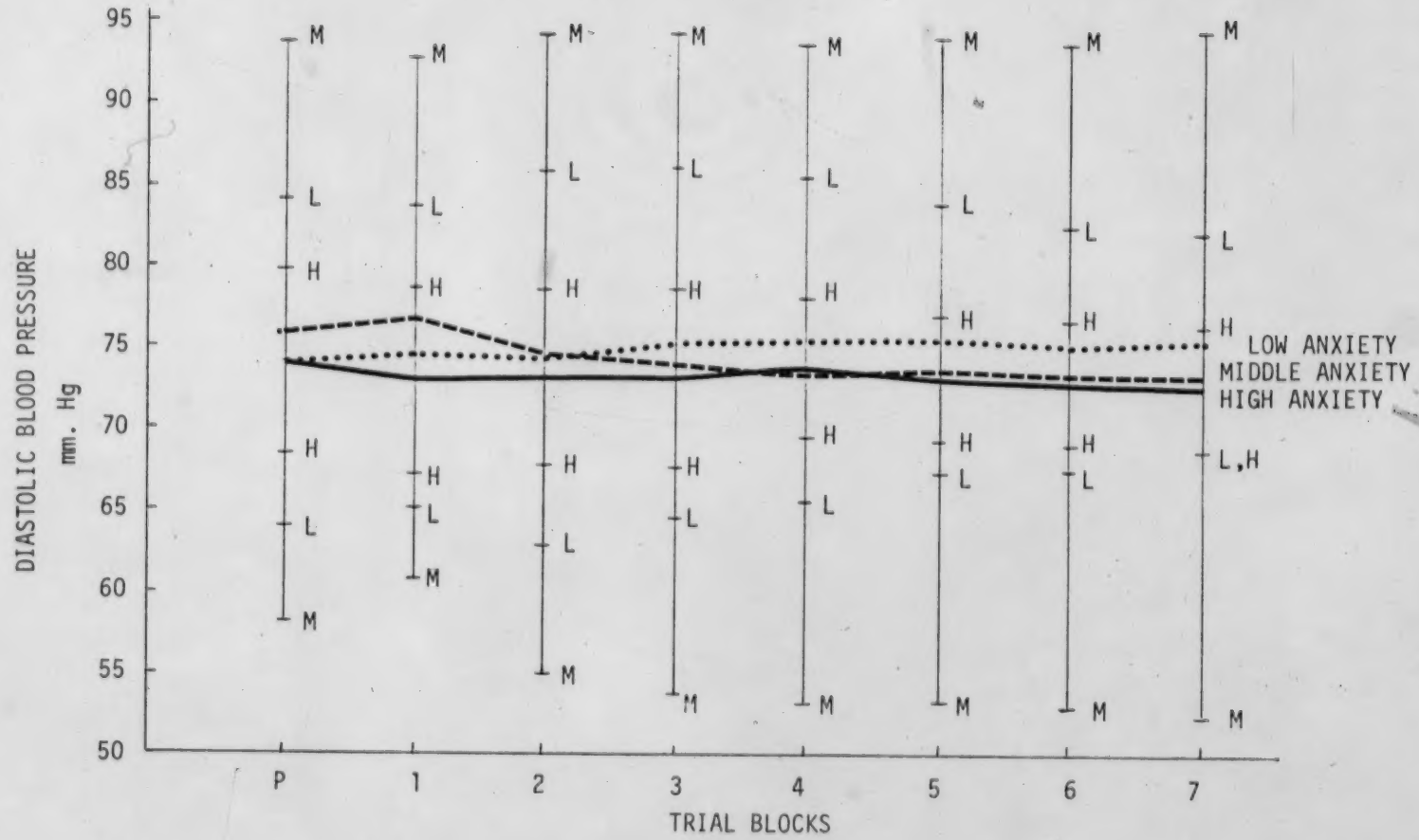

Figure 6: Mean diastolic blood pressure for the high, middle and low anxiety random groups, in blocks of five trials, for the 35 conditioning trials. The preliminary trials (P) consisted of the last trial before conditioning began. H, M, and L represent one standard deviation for the high, middle, and low anxiety groups respectively.

indicating that there were no significant differences in blood pressure between these groups.

TABLE 1

Preliminary Diastolic Blood Pressure for the Experimental Groups

GROUP	ANXIETY LEVEL		
	Low	Middle	High
Contingent	72	72	78
	78	82	90
	60	66	74
	58	56	86
	74	88	78
Random	78	88	84
	78	48	60
	50	68	72
	80	82	74
	76	84	72

Note: Blood pressures are given in mm Hg.

Blood pressure data were first analyzed for the two subject conditions (G), three anxiety levels (A) and seven trial blocks (T) using a three way ANOVA with one factor repeated (2 x 3 x 7). None of the F ratios were significant.

Figure 2 shows that as conditioning continued, the mean blood pressure dropped only slightly. From the ANOVA the T effect was not signi-

ficant, indicating that this trend was not significant. Table 2 shows that of the 30 Ss, 10 increased their blood pressure, 19 decreased theirs and one stayed about the same.

TABLE 2

Percentage Change in Diastolic Blood Pressure Between Initial and Final Conditioning Trials

GROUP	ANXIETY LEVEL		
	Low	Middle	High
Contingent	-8.8	-1.8	-2.3
	-0.5	-5.9	+3.5
	+1.9	-2.3	+9.9
	+6.3	-4.3	-14.4
	+8.0	+3.1	-5.4
Random	-2.0	-1.8	-4.0
	-3.1	-13.6	+5.0
	+16.3	-9.6	0.0
	-3.0	+1.9	-2.3
	-2.5	-0.5	+1.6

Figure 4 shows mean diastolic blood pressure for the three anxiety groups averaged over random and contingent conditions. The three-way ANOVA under consideration can only answer the question as to whether there was a significant difference between these groups when both random and contingent groups are combined. The high anxiety group

appears higher than the other two, but Figures 5 and 6 show that the higher mean blood pressure scores obtained by the high anxiety group was due to the large contribution of the high anxiety contingent group. From Table 3 it can be seen that the high anxiety contingent group had more than its share of Ss with high initial blood pressure. As can be seen from the analyses, the A main effect is not significant showing that there is no significant difference between blood pressure averaged over trials for the three groups. Likewise, the A x T interaction is not significant indicating the trends of the three groups are the same.

TABLE 3

Initial Diastolic Blood Pressure for the Experimental Groups

GROUP	ANXIETY LEVEL		
	Low	Middle	High
Contingent	72	88	102
	80	81	90
	63	68	87
	64	56	86
	80	89	82
Random	81	89	79
	78	47	64
	54	66	70
	80	84	70
	74	86	73

Note: Blood pressures are given in mm Hg.

One of the hypotheses to be tested was that the group receiving contingent feedback would decrease its blood pressure more than the group receiving random feedback. As can be seen from Figure 3, as conditioning began, the mean diastolic blood pressure of the random group remained almost unchanged while for the contingent group it increased rapidly over the first few trials and remained there for the duration of the experiment. Although the mean blood pressure for the random and contingent groups appear to differ considerably, from the ANOVA both the G main effects and the G x T interaction are not significant, indicating that blood pressure, averaged over trials, was not significantly different and that the form of the two curves are the same.

From Figures 5 and 6 it appears that for all three of the contingent groups mean blood pressure increased between the preliminary trials and the first five conditioning trials, while for the random groups this increase was much less (middle and low anxiety) or even a decrease (high anxiety).

In order to investigate this a three-way ANOVA with one factor repeated (2 x 3 x 2) was done for the two subject conditions (G), three anxiety levels (A), and two experimental conditions (preliminary trial with no biofeedback and first five conditioning trials with biofeedback).

Both the trial effects ($F = 5.86$, $df = 1/24$, $p < .05$) and the G x T interaction ($F = 5.09$, $df = 1/24$, $p < .05$) were significant. Figure 2 shows that for the random and contingent groups combined, blood pressure increased, which accounts for the significance of the Trials effect. From Figure 3 the contingent group increased its blood pressure considerably, while the random group's blood pressure stayed

the same.

One of the differences between the treatments received by the random and contingent groups was in the patterning of the feedback. Figure 7 shows a typical feedback schedule for contingent feedback Ss and Figure 8 shows a typical random feedback schedule. The difference is mainly that for the contingent feedback the curve is a sawtooth shape while for the random feedback there is no particular shape. This was because for the contingent feedback Ss, as blood pressure increased or decreased, the amount of feedback changed progressively over trials and then, when two trials with too few or too many feedbacks occurred, the cuff pressure was changed, resulting in a sudden increase or decrease in amount of feedback Ss received.

Table 4 shows the average number of feedback stimuli received by the contingent and random groups for the first five conditioning trials. For the first two trials the contingent Ss received considerably fewer feedback stimuli, but by the third trial they received as many as the random group. A test was done to determine if there was a significant difference between the amount of feedback received by the two groups. It was found that the contingent group received significantly less ($t = 2.00$, $df = 28$, $p < .05$) than the random group.

In order to investigate the overall differences in reactions of the three anxiety groups further three two-factor ANOVAs were done comparing high anxiety with low anxiety, high anxiety with middle anxiety and middle anxiety with low anxiety. Again, none of the F ratios were significant, indicating that there were no significant differences

between the diastolic blood pressure of the three groups and that the three curves were of the same form.

TABLE 4

Average Amount of Feedback Received by Groups for the First Five Conditioning Trials

GROUP	TRIALS				
	1	2	3	4	5
Random	24.4	19.6	18.9	21.5	27.7
Contingent	10.6	14.7	21.6	22.7	23.4

Note: Maximum score = 50.

One F ratio did approach significance at the .05 level and that was the T effect for the high and middle anxiety comparison. Figure 4 shows that both high and middle anxiety groups started with higher blood pressure than did the low anxiety group, but as the experiment continued their blood pressure decreased, while for the low anxiety group it remained the same.

In order to consider the results of the random and contingent groups the data from each group was analysed separately for the three anxiety levels (A) and seven trial blocks (T) using a two-way ANOVA with one factor repeated (3 x 7).

First the results for the contingent group will be considered.

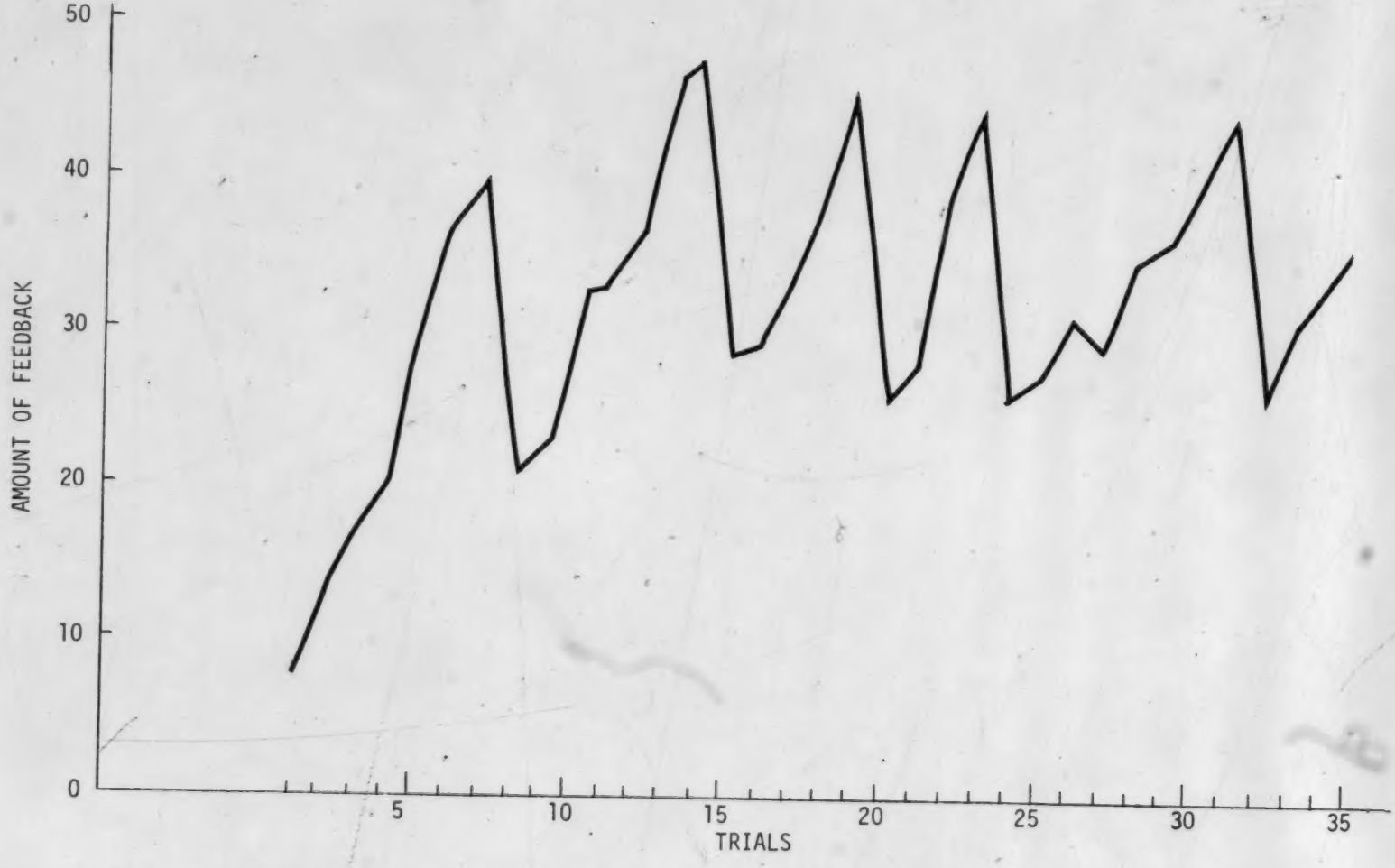

Figure 7: Typical feedback received by a contingent subject with decreasing blood pressure.

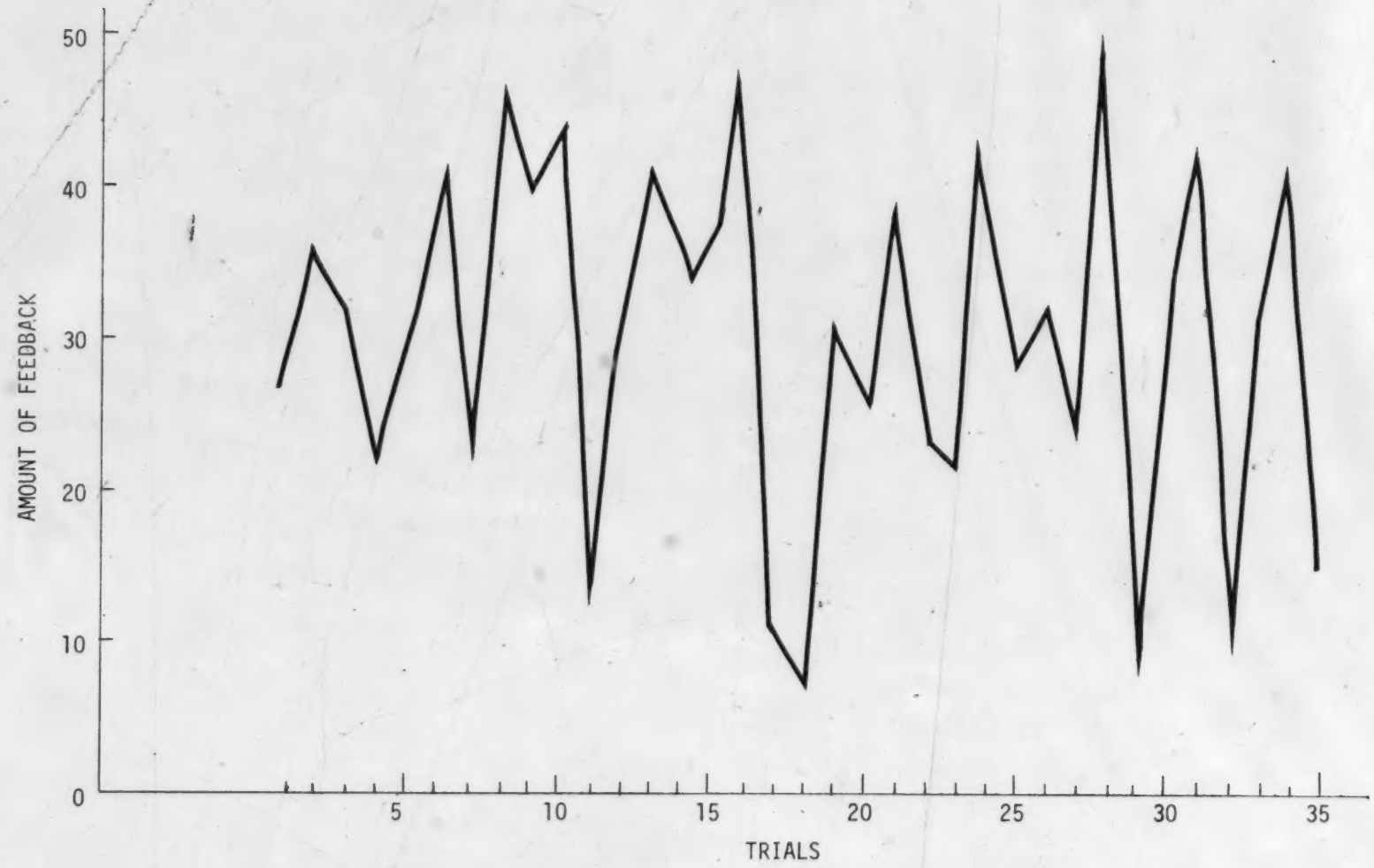

Figure 8: Typical feedback received by a random subject.

From Figure 5 it can be seen that none of the three groups decreased their blood pressure more than the others. The A x T interaction is not significant, which indicates the three curves are of the same form. This provided a test of the hypothesis that middle anxiety Ss would learn to decrease their blood pressure to a greater extent than high and low anxiety Ss.

The next question is whether the overall blood pressure of the contingent group decreased as the experiment proceeded. Figure 3 shows that the contingent group's mean blood pressure dropped slightly during the conditioning phase of the experiment. However, this trend was not significant as the T main effect was not significant. The mean blood pressure of the contingent group did not change significantly during the course of the experiment.

The final question is whether there was a difference between blood pressure averaged over trials between the three anxiety groups. Figure 5 shows that the high anxiety contingent group began with a much higher blood pressure which it maintained throughout the experiment. However, the lack of significance of the A main effect shows that these means do not differ significantly.

Next the random group will be considered. Examination of Figure 6 and the insignificance of the T main effect and the A x T interaction indicate that there were no differences in blood pressure levels between the groups or blood pressure changes during the conditioning procedure.

Figure 3 shows that the average blood pressure of the random group stayed much the same and the insignificance of the T main effect from

the analysis confirms that the blood pressure did not change as the experiment went on. The insignificance of the A main effect indicates that there was no difference in blood pressure averaged over trials between the three groups.

To determine if there were any relations of interest between any of the variables included in this experiment, three Pearson Product Moment Correlations were done; one for contingent and random groups combined, and one for each group separately. Included in these analyses were: (1) IPAT Anxiety scores, APQ scores and IE scores; (2) initial blood pressure, initial respiration rate and initial heart rate (the definition of 'initial' is the mean of the first five conditioning trials); (3) changes in blood pressure, heart rate and respiration rate (the mean for the last five conditioning trials minus the initial mean); and, (4) EMG activity and (5) a measure of state anxiety.

For the random and contingent groups combined, the only correlation coefficient to approach significance at the .05 level for blood pressure was that between initial blood pressure and anxiety level. This coefficient was 0.3132. Ss with high anxiety scores tended towards having a higher initial blood pressure.

For the contingent group separately, the correlation coefficient between initial blood pressure and anxiety score had a value of 0.6369 which is significant at the .05 level. Additionally, the correlation between initial blood pressure and IE score was 0.6840 which is significant at the .01 level. Ss with higher external scores tended toward having higher initial blood pressure. None of the other correlation

coefficients approached significance.

The correlation coefficient between change in blood pressure and IE score was 0.0301. Thus, the prediction that higher internal scorers would do better was not substantiated. There was no relationship between IE score and ability to control blood pressure using biofeedback.

For the random group the only correlation to approach significance was between change of blood pressure and initial heart rate. This correlation was 0.4954. Ss with a higher initial heart rate tended towards having a greater change in blood pressure.

It was predicted that middle APQ scorers would be more successful than high and low scorers at reducing their blood pressure using biofeedback. Because the predicted relationship was curvilinear, the eta correlation coefficient between APQ score and change in blood pressure was computed. This was done for both the contingent group by itself and for the contingent and random groups combined. Neither of the coefficients approached significance. Middle APQ scorers did not do better than low and high scorers.

Heart Rate

Figures 9, 10, and 11 show the mean heart rate for the preliminary and conditioning parts of the experiment. The five preliminary and 35 conditioning trials were grouped in blocks of five for analysis and graphic presentations.

Heart rate data was first analysed using a three-way ANOVA with one factor repeated for the two subject conditions (G), three anxiety levels (A) and seven trial blocks (T). Only one F ratio was significant

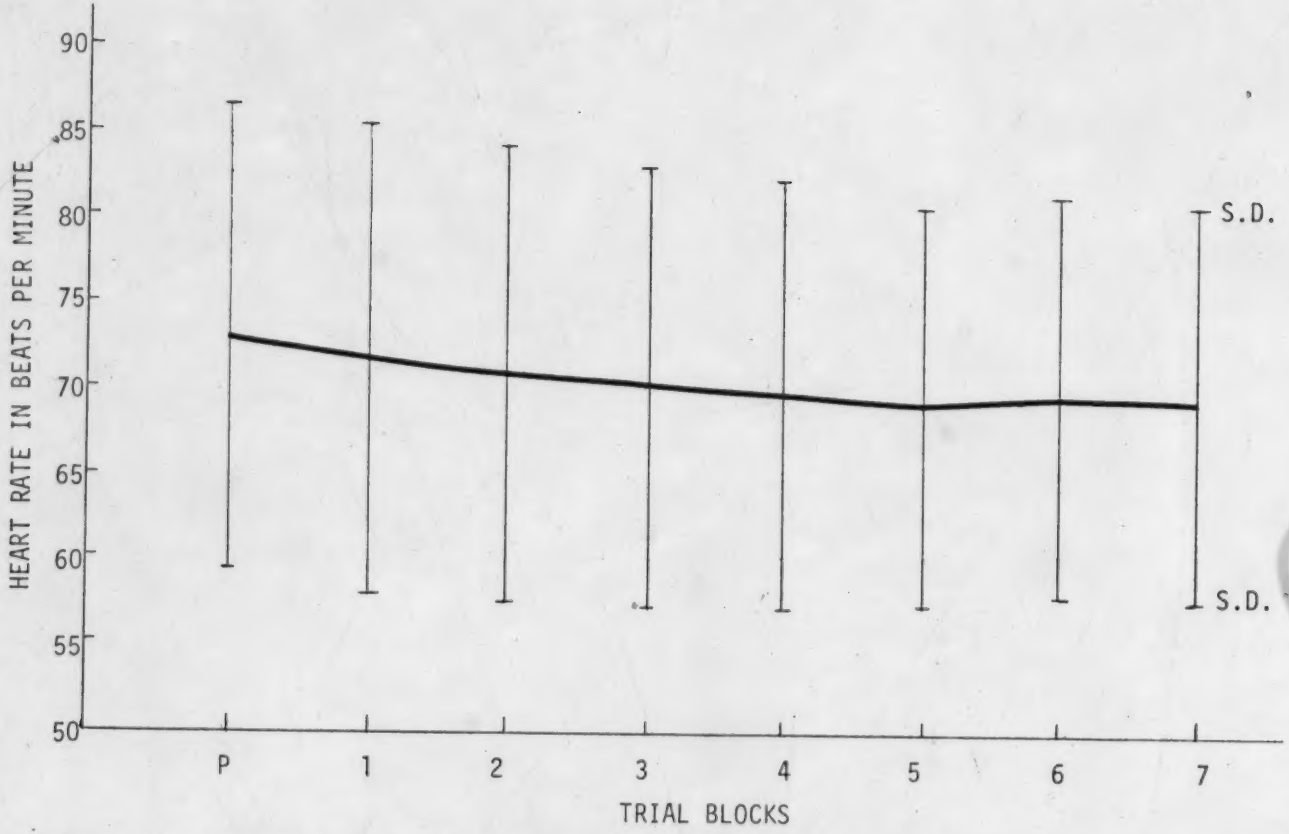

Figure 9: Mean heart rate for all subjects, in five trial blocks, for the 35 conditioning trials. The preliminary trials (P) consisted of the last trial before conditioning began. S.D. represents one standard deviation for the trial blocks.

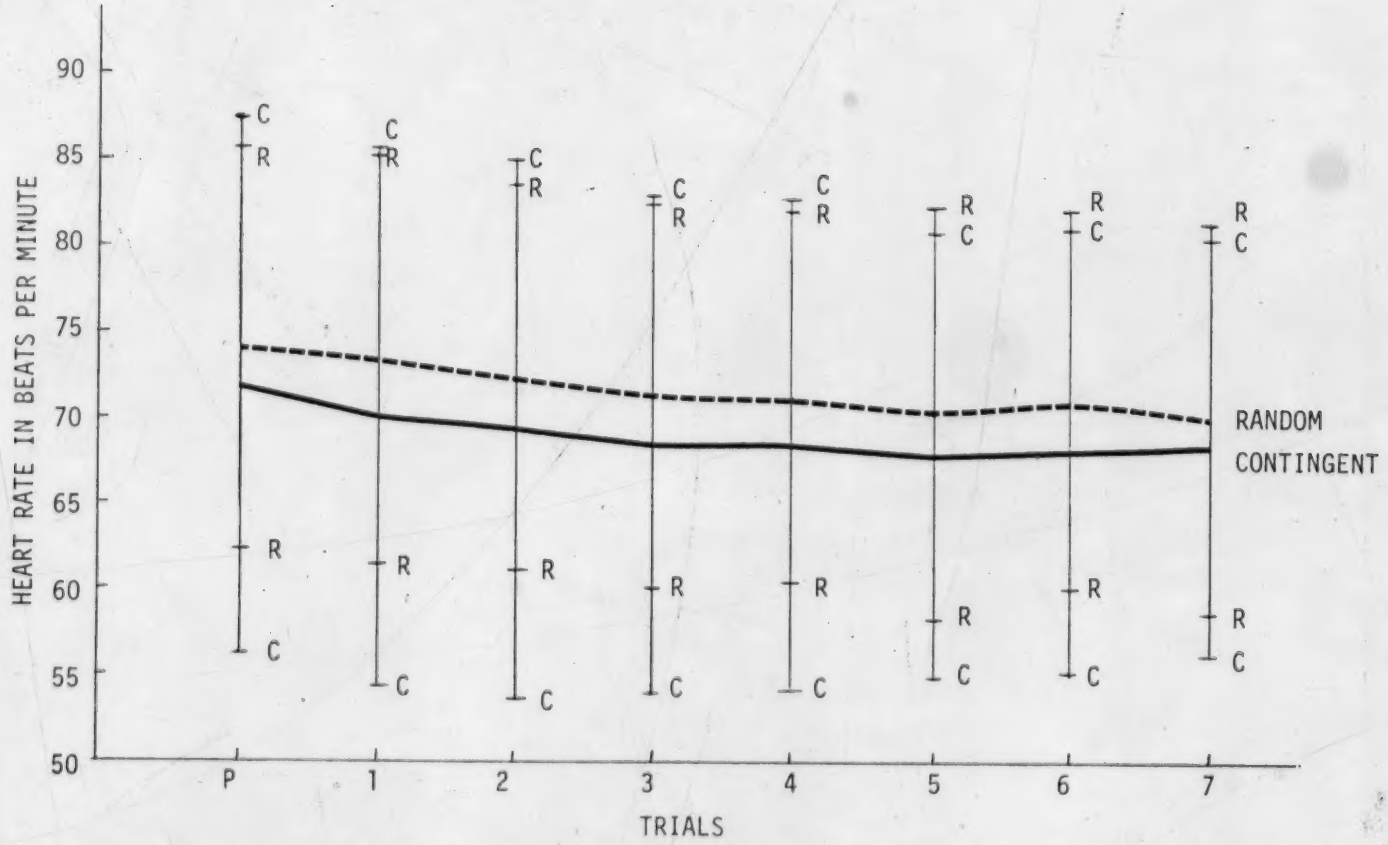

Figure 10: Mean heart rate for the random and contingent groups, in five blocks, for the 35 conditioning trials. The preliminary trials (P) consisted of the last trial before conditioning began. R and C represent one standard deviation for the random and contingent groups respectively.

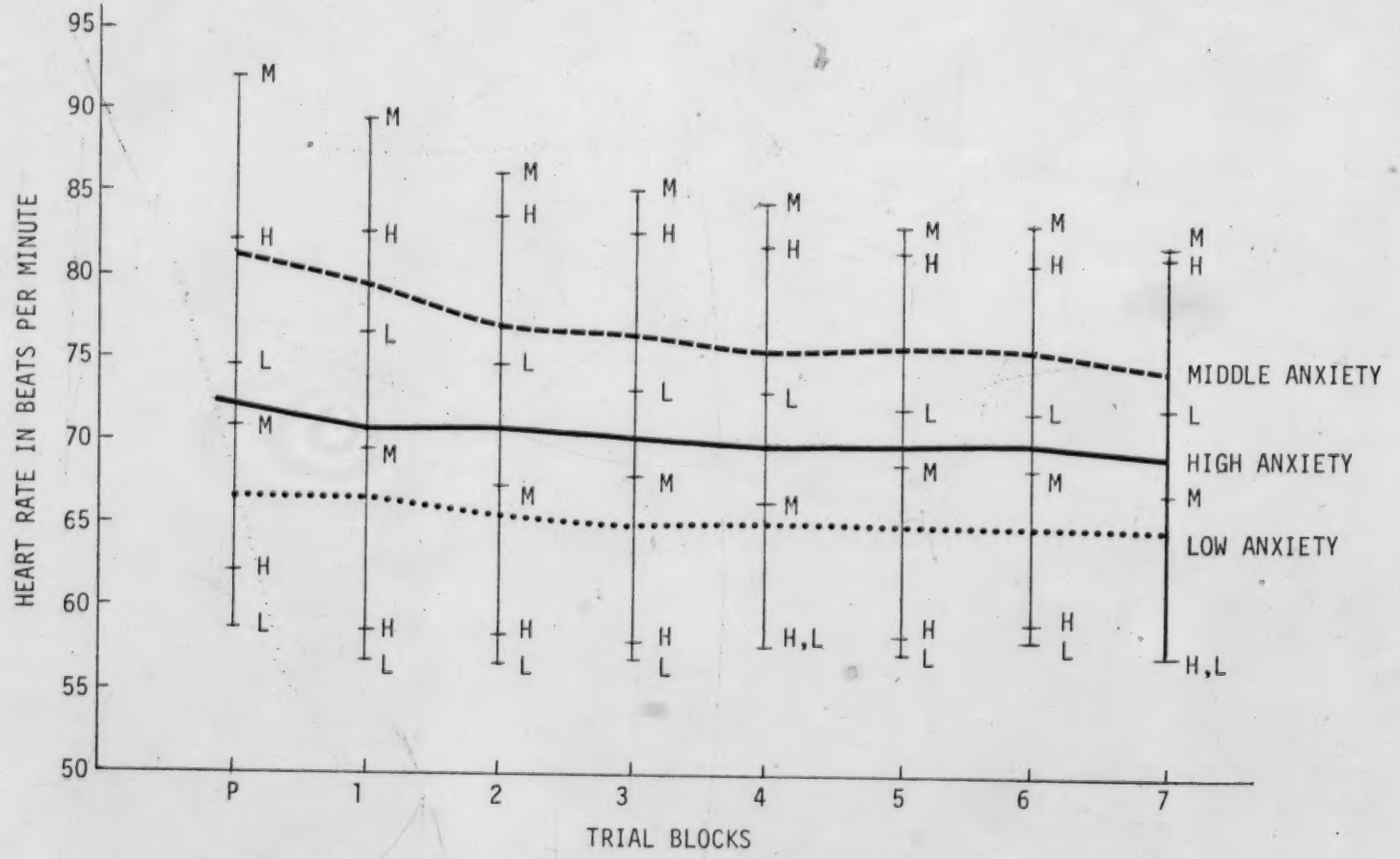

Figure 11: Mean heart rate for high, middle, and low anxiety groups, for all subjects, in five trial blocks, for the 35 conditioning trials. The preliminary trials (P) consisted of the last trial before conditioning began. H, M, and L represent one standard deviation for the high, middle, and low anxiety groups respectively.

and that was for trials (F = 5.39, df = 6/144, p < .01). From Figure 9 it can be seen that heart rate decreased as the experiment continued.

Figure 10 shows that the contingent Ss had a lower mean heart rate than the random group. However, the group main effect was not significant, indicating there was no significant difference between heart rates of the two groups averaged over trials. As well, the G x T interaction was not significant, indicating that the curves of the two groups were of the same form.

Figure 11 shows the mean heart rate of the three anxiety groups averaged over contingent and random conditions. The low anxiety group began with the lowest heart rate, which it maintained fairly constantly. The high anxiety group was between the middle and the low groups--mainly because of two Ss with very low heart rates. However, the difference between the three anxiety levels was not significant, as reflected by the insignificance of the A main effects. Although the middle anxiety group appears to be decreasing its heart rate to a greater extent than the other two groups, the A x T interaction is not significant, showing that the three curves are of the same form.

In order to determine if there was a difference between low and middle anxiety groups, which from Figure 11 appear to be the furthest apart, a two-way ANOVA with one factor repeated was done for two anxiety levels (A) and seven trial blocks (T). Again, the only F ratio that was significant was that for trial blocks (F = 4.70, df = 6/108, p < .01). There were no significant differences between low and middle anxiety groups for heart rate.

As for blood pressure, Pearson Product Moment correlation coeffi-

cients were computed for initial heart rate and change in heart rate. For the random and contingent groups combined, the only correlation coefficient which was significant was that between initial heart rate and change of heart rate. This coefficient was 0.5545 which is significant at the .01 level. Ss with higher initial heart rates had a greater decrease in their heart rates as the experiment proceeded.

For the contingent group, as with the random and contingent group combined, the only correlation coefficient to reach significance was that between initial heart rate and change in heart rate. The coefficient was 0.6647, which is significant at the .01 level.

For the random group the correlation coefficient between initial heart rate and change in heart rate was 0.4564, which did not quite reach significance at the .05 level. For this group, initial heart rate was also correlated fairly highly with IE score and change in blood pressure. The coefficients were 0.4453 and 0.4954, respectively. Ss with higher external scores tended to have a higher initial heart rate than did low scorers and Ss with higher initial heart rates tended to have a greater change in blood pressure over time.

Respiration Rate

Figures 12, 13, and 14 show the mean respiration rate for the conditioning trials, grouped in blocks of five trials. Respiration rate data was analysed using a three-way ANOVA with one factor repeated for the two subject conditions (G), three anxiety levels (A), and seven trial blocks (T). None of the F ratios were significant.

Figure 13 shows that the random group decreased their mean

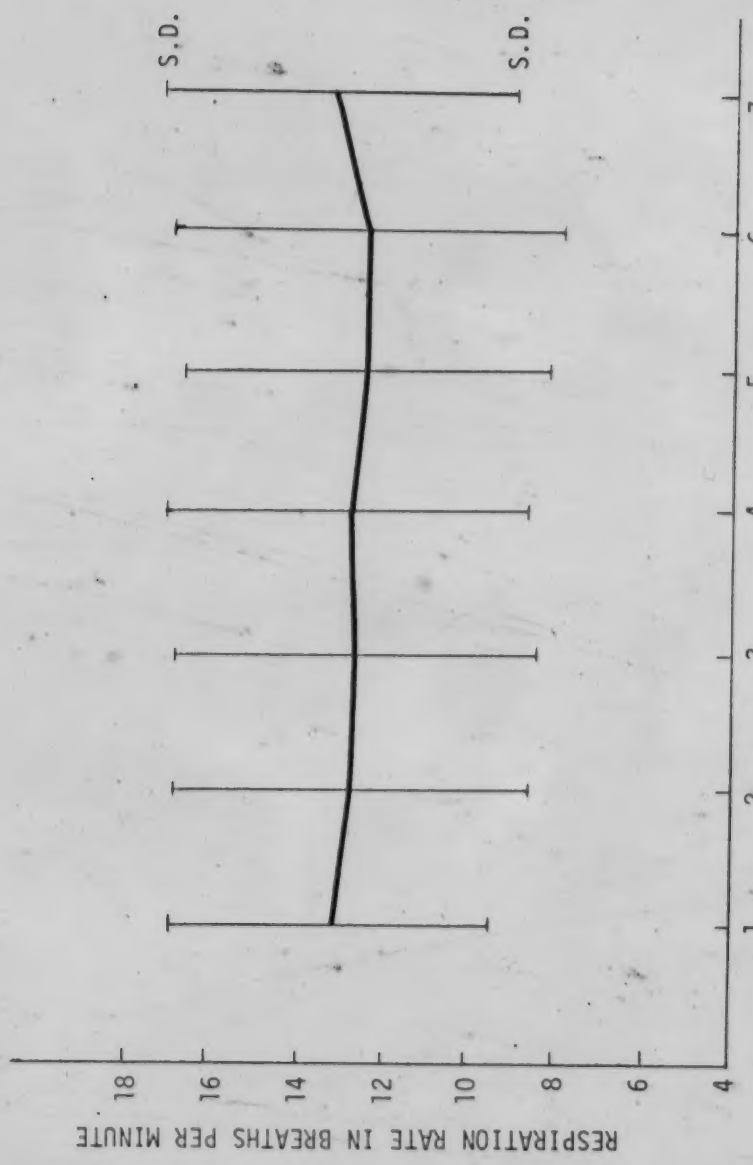

Figure 12: Mean respiration rate for all subjects, in blocks of five trials, for the 35 conditioning trials. S.D. represents one standard deviation for the trial blocks.

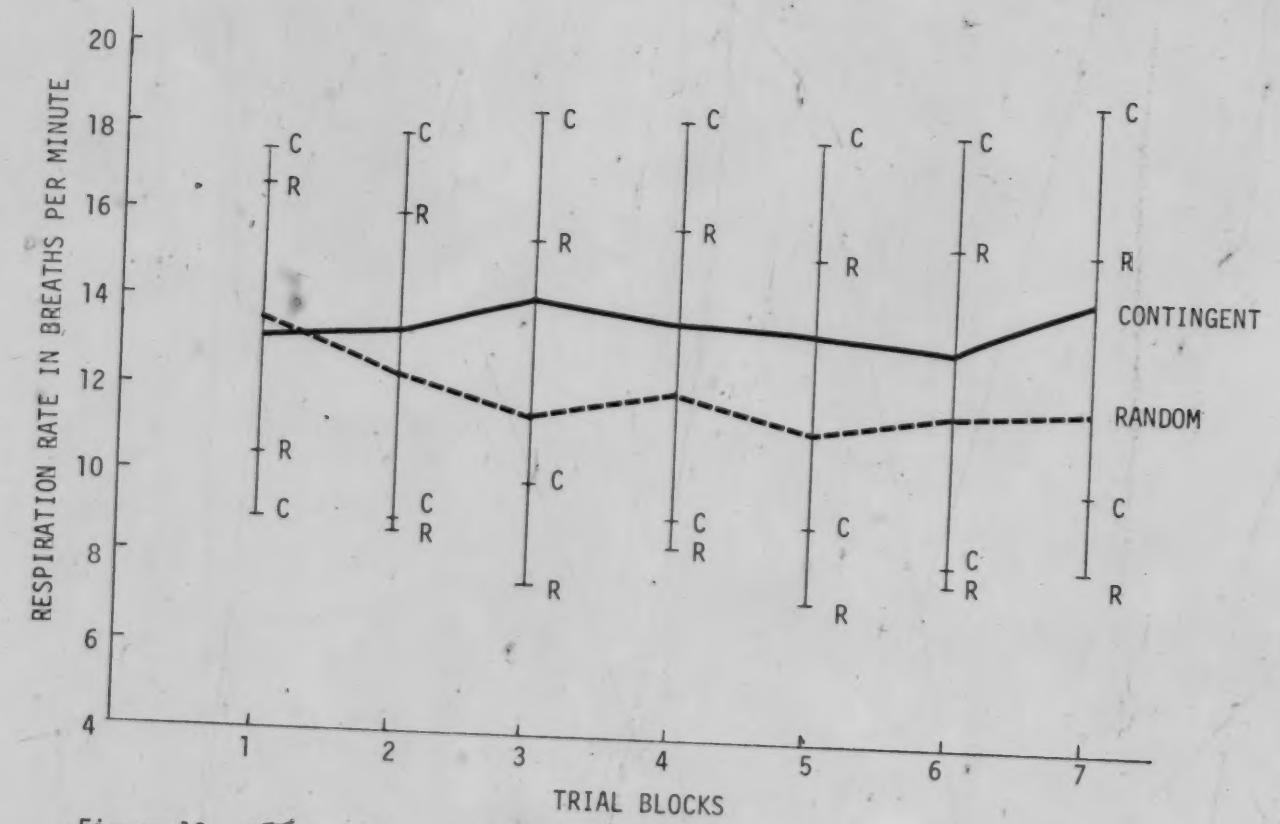

Figure 13: Mean respiration rate for random and contingent groups, in blocks of five trials, for the 35 conditioning trials. R and C represent one standard deviation for the random and contingent groups respectively.

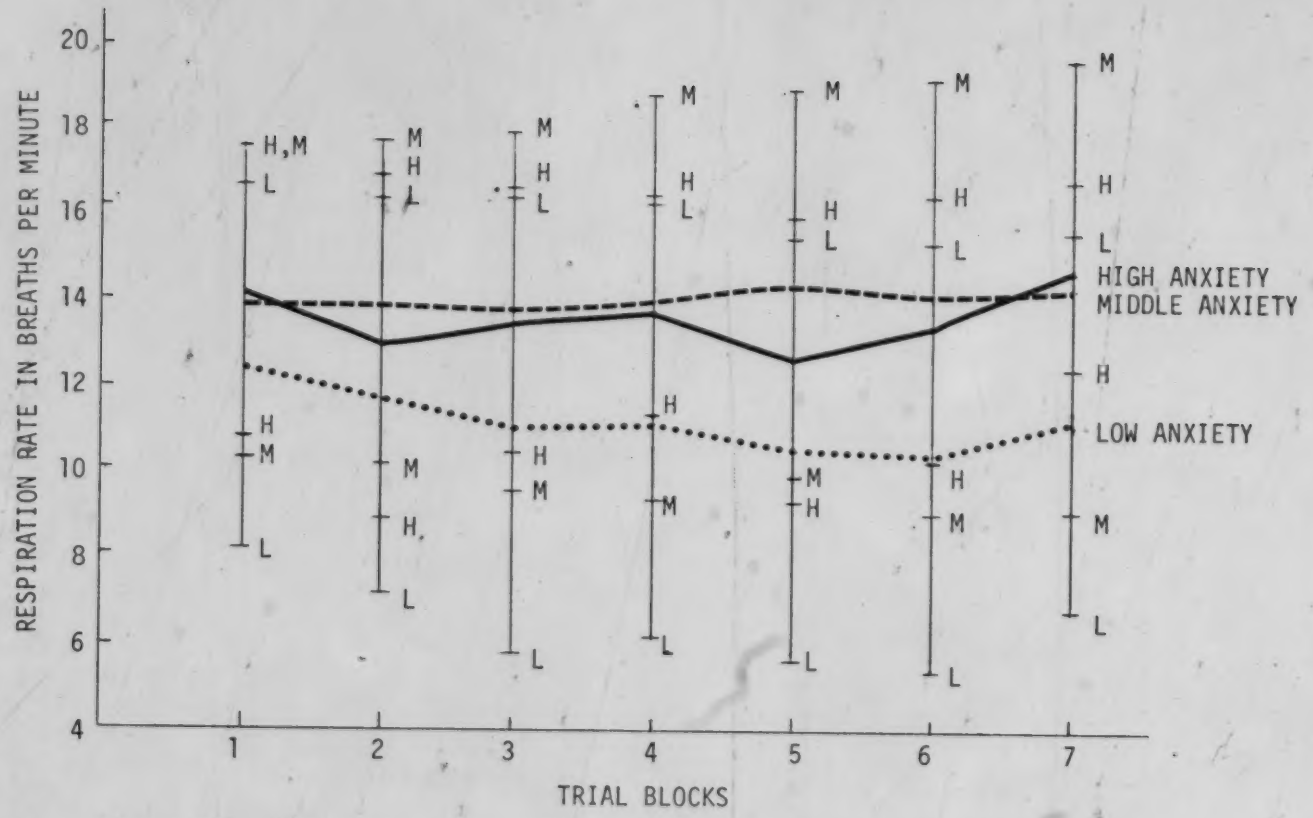

Figure 14: Mean respiration rate for high, middle and low anxiety groups for all subjects, in five trial blocks, for the 35 conditioning trials. H, M, and L represent one standard deviation for the high, middle, and low groups, respectively.

respiration rate, while the contingent group increased theirs. The A main effect for this was not significant. However, the G x T interaction approaches significance at the .05 level, indicating that the two curves are not of the same form. Thus, there was a nonsignificant trend toward decreased respiration rate for the random group, while that of the contingent group increased.

Although from Figure 14 the low anxiety group has a lower mean respiration rate, which decreases even more as the experiment progresses, neither the A main effect or the A x T interaction approaches significance. There are no significant differences between these groups.

From Figure 12 it can be seen that the overall mean respiration rate for all groups combined did not change as the experiment proceeded. This is reflected by the insignificance of the T effect.

Correlation coefficients were computed between initial respiration rate, change in respiration rate, IPAT score, APQ score, IE scale score, initial blood pressure, initial heart rate, change in blood pressure, change in heart rate and EMG activity. For the contingent and random groups combined, the correlation between change in respiration rate and IE score was 0.4616, which is significant at the .05 level. Ss with higher external scores decreased their respiration rates less as the experiment proceeded than did low external scorers. As well, initial respiration rate correlated 0.4146 with APQ score, which is significant at the .05 level. Ss with higher APQ scores had a higher initial respiration rate than did low scorers.

For the contingent group by itself, initial respiration rate and change in respiration rate were correlated 0.6647, which is significant

at the .01 level. For this group Ss with higher initial respiration rates decreased their respiration rate to a greater extent than did those with a lower initial rate. Change of respiration rate was correlated 0.5032 with IE score which does not quite reach significance at the .05 level.

For the random group initial respiration rate and change in respiration rate were correlated 0.6743, which is significant at the .01 level. Ss with a higher initial respiration rate decreased their rate to a greater extent than did Ss starting with a low rate. As well, initial respiration rate was correlated 0.7497 with APQ score which is also significant at the .01 level. Ss with a higher initial respiration rate had higher APQ scores.

Change in respiration rate was correlated 0.4790 with APQ score and 0.3772 with IE score, neither being significant. Ss with larger decreases in respiration rate tended to have lower external and higher APQ scores.

EMG activity was correlated with the other variables in the experiment. It had a correlation of 0.3157 with initial blood pressure--which is not quite significant at the .05 level. Ss with a higher initial blood pressure tended to have more EMG activity. None of the other correlations approached significance.

Correlation coefficients were also computed between personality measures. The APQ and IPAT anxiety score were correlated 0.3735 which is significant at the .05 level. The IPAT anxiety and IE scale were correlated 0.3328 which was not quite significant at the .05 level.

The correlation between the anxiety scale and the measure of state anxiety derived from the questionnaire was 0.3602 which is just significant at the .05 level.

Questionnaire Results

The questionnaire was given to get a general idea of how Ss reacted to the experiment and to see if there were any differences between random and contingent groups in their perception of what happened to them. The first question asked Ss was which physiological function they thought they were attempting to control. Seven out of 30 Ss answered correctly, four in the contingent group and three in the random group.

The next question was whether they felt they had succeeded or not. Twelve felt they had not (six in each of the groups), eight felt they had part of the time (four in each group), and 10 felt they had (five in each group). In the contingent group, four out of five who felt they had succeeded actually did decrease their blood pressure, while three out of four who felt they had part of the time also decreased theirs. Of those who felt they did not succeed, four out of six increased their blood pressure.

Ss in the contingent group who did decrease their blood pressure said they did it by "trying not to try", "visualizing getting angry", "breathing regularily", "keeping thoughts to a minimum", and "relaxing." Those who increased their blood pressure "tried to be happy", "concentrated on pleasing pastimes", "stopped looking at pictures", and "emptied my lungs." According to the subjective reports, there seemed to

be no differences between methods which increased blood pressure and those which decreased it.

In the fourth question Ss were asked if there was anything that upset them or made them anxious. Out of the 11 that said "yes", five became anxious when they could not get the light to flash, two were concerned when they first saw the apparatus but felt better later, one did not like being paid, one felt anxious in anticipation of the cuff being inflated, and two did not like the cuff pressure. At the end of the experiment several Ss mentioned that the sudden inflation of the cuff in the quiet room disturbed them--it was as if someone had grabbed them from behind.

Question five asked if any discomfort had been felt at any time. Half of the Ss reported that they had. Eleven of these complaints were due to the requirement of sitting still in a small room (e.g., boredom, leg falling asleep, wanting to stretch, and becoming sleepy). Four felt discomfort due to the blood pressure cuff. However, it was very slight.

Question six was a three-part question which asked Ss how they felt at the beginning, half-way through, and at the end of the experiment. For their answer they were to choose from a group of words ranging from "terrified" to "asleep." No one said they were terrified, six said they were anxious at some time, four said they were concerned at some time, and the rest varied their answers between interested, relaxed, and sleepy. No one fell asleep.

Ss did not appear to consider the monetary reward for increased

performance as very motivating. Several seemed to be offended when told they would be paid according to how well they did and one came right out to voice her feelings about it. At the end of the experiment, several Ss said they did not care if they received their money or not. Of all 30 Ss, only one demonstrated any enthusiasm when told he could earn extra money by improved performance.

CHAPTER IV

DISCUSSION

Several studies have used biofeedback procedures in the treatment of essential hypertension (Benson, Shapiro, Tursky & Schwartz, 1971; Krist & Engel, 1975). Results from these studies indicated that they were successful. Research prior to these clinical studies used normotensive Ss and obtained significant differences between groups reinforced for increasing or decreasing their blood pressure (Shapiro, Schwartz & Tursky, 1972; Shapiro, Tursky, Gershon & Stern, 1969; Shapiro, Tursky & Schwartz, 1970a, 1970b). However, neither of these types of studies can clearly demonstrate the usefulness of biofeedback training in the treatment of hypertension. In the studies using biofeedback for treating hypertension, there were undoubtedly strong placebo effects (Strobel & Glueck, 1973). In those studies comparing groups reinforced for increasing or decreasing their blood pressure, the significance of the results may have been due to (a) the increase group maintaining blood pressure rises resulting from experimental stress and (b) the decrease group relaxing and thus decreasing theirs. Although such significant differences indicate a certain amount of control over blood pressure, it does not provide evidence of clinical usefulness.

In order to demonstrate such clinical usefulness it must be shown that blood pressure decreases using biofeedback procedures are significantly greater than blood pressure decreases resulting from habituation

or adaptation to the novelty of the experimental situation. The simplest solution is to employ a control group which receives the same instructions and type of stimuli as the experimental group, but, with the stimuli presented in some noncontingent manner. If the contingent group shows an increased rate of response relative to the noncontingent group, then the conclusion can be drawn that some form of contingency effect is operating (Crider, Schwartz & Schnidman, 1969). This study attempted to do this by comparing the results of one group which received feedback contingent on its own blood pressure with a group which received random feedback.

Results showed no significant differences in diastolic blood pressure between the contingent and random groups over the 35 conditioning trials. However, there was a significant difference between these groups when preliminary blood pressure (taken before conditioning began) and initial blood pressure (taken during the first five trials) was considered. During this phase of the experiment the random group maintained its mean diastolic blood pressure at a constant level while the contingent group increased theirs.

Almost all individuals will react to stress of any type with a rise in blood pressure (Malmo & Shagass, 1952). In this experiment, when Ss were told they were to begin their task they likely became somewhat anxious which led to an increase in blood pressure. For the contingent group this increase in blood pressure would have resulted in a decrease in the amount of feedback being received. This was due to diastolic blood pressure having to be below the constant cuff pressure

before feedback was given. Concern over this failure may have caused some Ss to increase their blood pressure even more which in turn resulted in still less feedback. Because the procedure called for two trials of less than 13 artery sounds per trial before the cuff pressure could be changed to track blood pressure, several trials were required to catch up. When the cuff pressure finally caught up with the blood pressure, S began receiving more feedback. One very nervous S increased his blood pressure 24 mm Hg during this lag in feedback.

Under random feedback conditions even if Ss' blood pressure did increase, feedback was unaffected. Consequently, no such vicious circles were begun in the random group. When the amount of feedback received by each group was analysed for the first five conditioning trials, it was found that the random group received significantly more than did the contingent group. Such a difference in feedback contingencies could account for the significant increase in blood pressure of the contingent group, in comparison to the random group, during this phase of the experiment.

This increase in blood pressure between the preliminary no feedback phase and the feedback phase was also found in other studies using similar procedures (Shapiro, Tursky, Gershon & Stern, 1969; Shapiro, Tursky & Schwartz, 1970a). In these studies this initial blood pressure increase was followed by a maintenance of this level by the group reinforced for increasing blood pressure, while the group reinforced for decreasing blood pressure reduced theirs. Statistical analyses found significant differences between these two conditions. This was

interpreted to mean that blood pressure had been conditioned (Shapiro, Tursky, Gershon & Stern, 1969).

What may have really happened, however, was that the increase group used biofeedback to maintain the blood pressure increase caused by the initial stress of beginning the task, while the decrease group, after their initial increase, relaxed when they began to receive more feedback and thus their blood pressure dropped. Therefore, rather than learning to control blood pressure, all that happened was the increase group used biofeedback to maintain a high level of blood pressure. Although this reflects a certain amount of blood pressure control, it would not be of much use clinically.

If this interpretation of the results of these experiments is correct, it does not mean that blood pressure control can not be learned. It simply casts doubt on the conclusion that control can be learned in such a short time.

If such experiments are to be used to determine if blood pressure really can be operantly conditioned there are several additions which might allow for more conclusive results. Ss could be run for more than one experimental session. The learning of a skill takes practice and there is no reason to believe that this does not apply to the autonomic system as well as the voluntary system. Repeated exposure to the experimental situation would also decrease the initial blood pressure rise and so eliminate this artifact.

Another useful addition would be to provide Ss with more information about their performance. As the cuff pressure changed to track

blood pressure, the changes in the amount of feedback received by Ss was no doubt confusing. In some cases the feedback received by Ss being reinforced for decreasing their blood pressure may have actually conditioned a rise in blood pressure. For the down Ss, who found the lack of feedback at the beginning of the experiment upsetting, and who in turn increased their blood pressure, there often was a considerable rise in blood pressure and likely a rise in anxiety level before the cuff pressure caught up with blood pressure and the amount of feedback increased. Although the increase in feedback resulted from this catching up, to Ss the response actually rewarded was an increase in blood pressure. This was reflected by the report of Shapiro, Tursky and Schwartz (1970a) in which most members of both increase and decrease conditions seemed to infer that the experimenter wanted them to get excited.

An apparatus to provide more information would be a vertical line of lights with a yellow light in the middle, a number of green lights below, and a number of red lights above. The middle light would remain on and would represent beginning blood pressure. If blood pressure decreased, the green lights would be progressively turned on, an additional one on each trial the cuff pressure was decreased. If blood pressure increased, the red lights would be turned on (or green lights turned off if S had previously decreased his blood pressure).

This would prevent Ss from being confused when there were sudden changes in amount of feedback with no change in response. An S who had received a large amount of feedback and whose task was made more

difficult by a decrease in cuff pressure would realize what was going on. As well, a counter could be supplied which would provide a better idea as to performance from trial to trial.

In any experimental or clinical situation one of the problems is motivation. In biofeedback experiments Miller (1969) suggested that feedback for controlling the function in and of itself may be all that is necessary. This appears to be true in the control of some physiological functions. For example, in alpha brain wave studies Ss were willing to work simply in order to increase the amount of feedback they received (Nowlis & Kamiya, 1970).

However, in blood pressure studies both money and pictures were required to provide motivation (Schwartz, 1973). Lack of success in the present study may have been partially due to the fact that most Ss were not interested in the money. Several were even offended when informed they would be paid in accordance with their performance. Also, because both males and females were used in this study, pictures of nude females were not included as Shapiro, Tursky, Gershon and Stern (1969) and Shapiro, Tursky and Schwartz (1970a) did in theirs.

The reason for the difference in motivation between blood pressure studies and the others may be in the type of feedback received. When biofeedback is used for most physiological functions S receives feedback only when he succeeds in producing the correct response. For example, in alpha brain wave research, S receives feedback only when alpha is produced (Nowlis & Kamiya, 1970). However, in blood pressure biofeedback experiments, S receives 50% reinforcement without controlling

anything. When blood pressure does change in the appropriate direction the amount of feedback increases to 75% reinforcement and then suddenly decreases back to 50% when the cuff pressure is changed to match the new blood pressure level. This sort of pattern is not likely to be very rewarding.

One way to increase the motivational power of the feedback in blood pressure biofeedback research might be to give more information about performance. The apparatus already described, consisting of a vertical line of red, yellow and green lights, would provide this information. This would give Ss something more to work toward than trying to increase the amount of feedback over and over again. Brener and Kleinman (1970) provided their Ss with a manometer gauge and a counter and made no mention of any problems of motivation. However, their study used blood pressure in the index finger and thus there is no way to ascertain how general the effect was.

In previous studies in which reinforcement was given for decreasing blood pressure Ss were successful in significantly decreasing their blood pressure over trials (Shapiro, Schwartz & Tursky, 1972; Shapiro, Tursky, Gershon & Stern, 1969; Shapiro, Tursky & Schwartz, 1970a, 1970b). However, in the present study the group which received contingent feedback for blood pressure decreases did not decrease their blood pressure over trials. There were several differences between the previous studies and the present one that might account for this lack of replication.

First of all, Ss in the successful studies were volunteers, whereas

the ones in the present one were not. Research has indicated that volunteers for any type of experiment are not representative of the general population. For example, volunteers for hypnosis research had a more favorable attitude toward hypnosis (Zamansky & Brightbill, 1965) and volunteers for interviews about sexual attitudes had more sexually permissive attitudes than nonvolunteers (Siegman, 1956). It is very likely that volunteers for biofeedback research would be more informed about, and have a more favorable attitude toward biofeedback as well as to experimental situations in general. In turn, volunteers would be more likely to relax in an experimental situation than would nonvolunteers and so undergo spontaneous decreases in blood pressure.

Secondly, the previous studies used only male Ss and some of the pictures used for motivating them were of nude females. This may have been more interesting for the Ss and prevented them from becoming bored and restless as they appeared to be in the present experiment. It is also possible that these pictures were more motivating and caused Ss to try harder. Additionally, some of the volunteers may have participated for the money involved. They would therefore have been more motivated than many of the Ss in the present experiment who did not appear to be interested in monetary gain.

The other aim of this study was to determine if the ability to learn control of blood pressure using biofeedback could be predicted. Three objective personality tests were used for this purpose: The IPAT Anxiety Scale Questionnaire (Cattell & Scheier, 1963); Rotter's (1966) I-E Scale; and the Autonomic Perception Questionnaire (Mandler,

Mandler & Uviller, 1958). None of these tests were successful.

This failure was likely due to none of the Ss learning the task. These tests were able to predict success in the conditioning of other physiological functions--the APQ in heart rate conditioning (Blanchard, Young & McLeod, 1972) and GSR (Greene & Nielson, 1966), the I-E in alpha conditioning (Johnson & Meyer, 1974; Wagner, Bourgeois, Levenson & Denton, 1974), and an anxiety questionnaire in heart rate conditioning (McFarland & Coombs, 1974). In these studies Ss were given about the same amount of practice as in the present experiment. It may be that blood pressure control is more difficult to learn and thus requires more practice.

All groups showed a significant trend toward a decrease in heart rate over trials. This replicates what was found in other blood pressure biofeedback trials (Shapiro, Tursky, Gershon & Stern, 1969; Shapiro, Tursky & Schwart, 1970a). Increased respiration rate, heart rate and blood pressure are all considered part of the physiological response of anxiety (Cattell & Scheier, 1961). Therefore, it would be expected that if one of these functions decreased significantly, then all of them would. However, in the present study only heart rate decreased significantly, while respiration rate and blood pressure did not. A possible explanation may be that in this case a decreased heart rate did not reflect a decrease in anxiety state, but rather a finding by Lacey, Kagan, Lacey and Moss (1963) that when Ss were required to attend to visual and auditory inputs their heart rates dropped.

The main finding of this study was that Ss did not learn to

control their blood pressure using procedures which appeared successful in other experiments. However, evidence was found which suggested that the positive findings of these other studies may have been due to a flaw in procedures. It appears that Ss may not really have learned to control their blood pressure, but rather, one group maintained a blood pressure increase caused by the initial stress of beginning the experiment, while the other group decreased theirs by relaxing. This leads to the conclusion that blood pressure conditioning is not impossible, but it may be more difficult to learn than these experiments would lead us to believe.

Future research should be done comparing the results of contingent reinforcement with random reinforcement. Ss provided with more practice and increased information about their performance might produce more meaningful information about the possibility of the clinical usefulness of such procedures.

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APPENDIX A

POST EXPERIMENTAL QUESTIONNAIRE

QUESTIONNAIRE

1. What physiological response or responses do you think you were attempting to control?

2. Do you think that you succeeded?

3. If you feel that you succeeded, how did you do so? (i.e., What was it that you did to make the red light flash on?)

4. Was there anything about this experience that upset you or made you anxious at any time?

5. Did you feel any discomfort at any time?

6. From the list below, pick out the word that best describes how you felt: TERRIFIED, ANXIOUS, CONCERNED, INTERESTED, RELAXED, SLEEPY ASLEEP

   (a) at the beginning of the experiment _____.
   (b) half way through _____.
   (c) at the end _____.

7. Any comments?

APPENDIX B

ANALYSIS OF VARIANCE TABLES FOR BLOOD PRESSURE

Analysis of Variance for Blood Pressure of Random and Contingent Groups, High, Middle and Low Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Groups (G)	1	0.26	2.46
Anxiety Level (A)	2	0.11	1.01
Trials (T)	6	1.07	0.41
A x G	2	0.17	1.65
G x T	6	0.18	0.41
A x T	12	0.36	0.80
A x G x T	12	0.21	0.46

Analysis of Variance for Blood Pressure of the Contingent Group, High, Middle and Low Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Anxiety Level (A)	2	27.51	2.98
Trials (T)	6	4.63	0.75
A x T	12	2.81	0.45

Analysis of Variance for Blood Pressure of the Random Group, High, Middle and Low Anxiety Levels, and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Anxiety Level (A)	2	45.00	0.38
Trials (T)	6	2.19	0.76
A x T	12	2.73	0.94

Analysis of Variance for Blood Pressure of High and Middle Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Anxiety Level (A)	1	12.65	0.85
Trials (T)	6	9.17	2.08
A x T	6	1.98	2.08

Analysis of Variance for Blood Pressure of High and Low Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Anxiety Level (A)	1	18.70	2.54
Trials (T)	6	2.50	0.48
A x T	6	2.81	0.54

Analysis of Variance for Blood Pressure of Middle and Low Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Anxiety Level (A)	1	58.75	0.05
Trials (T)	6	1.98	0.62
A x T	6	5.21	1.62

Analysis of Variance for Blood Pressure of Random and Contingent Groups, High, Middle and Low Anxiety Levels and Preliminary and Initial Trials

SOURCE	DF	MS	F
Groups (G)	1	0.31	1.15
Anxiety Level (A)	2	0.35	1.30
Initial and Preliminary Trials (IPT)	1	0.52	5.86*
G x A	2	0.51	1.91
G x T	1	0.45	5.09*
A x G x T	2	0.25	0.29

* $p < .05$

APPENDIX C

ANALYSIS OF VARIANCE TABLES FOR HEART RATE

Analysis of Variance for Heart Rates of the Random and Contingent Groups, High, Middle and Low Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Group (G)	1	0.15	0.41
Anxiety Level (A)	2	0.88	2.33
Trials (T)	6	0.11	5.39*
A x G	2	0.56	1.50
G x T	6	0.17	0.80
A x T	12	0.22	1.03
A x G x T	12	0.13	0.58

* $p < .01$

Analysis of Variance for Heart Rate of Middle and High Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Anxiety Level (A)	1	488.01	1.17
Trials (T)	6	11.44	4.71*
A x T	6	3.41	1.40

* $p < .01$

APPENDIX D

ANALYSIS OF VARIANCE TABLES FOR RESPIRATION RATE

Analysis of Variance for Respiration Rate of the Random and Contingent Groups, High, Middle and Low Anxiety Levels and Seven Blocks of Conditioning Trials

SOURCE	DF	MS	F
Group (G)	1	0.18	0.74
Anxiety Level (A)	2	0.24	0.97
Trials (T)	6	0.49	0.81
A x G	2	0.97	0.39
G x T	2	0.11	1.86
A x T	12	0.43	0.72
A x G x T	12	0.43	0.71

APPENDIX E

TABLES OF CORRELATION COEFFICIENTS

Correlation Coefficients for All Groups Combined

	IPAT	APQ	IE	CBP	CHR	CRR	IBP	IHR	IRR	EMG	SA
IPAT	1.00										
APQ	0.37*	1.00									
IE	0.32	0.14	1.00								
CBP	-0.14	-0.11	-0.01	1.00							
CHR	-0.12	0.06	-0.10	-0.07	1.00						
CRR	-0.18	-0.22	-0.46*	-0.12	0.22	1.00					
IBP	0.31	-0.13	0.24	-0.04	0.07	-0.11	1.00				
IHR	-0.15	-0.25	0.25	0.17	-0.55**	-0.14	0.01	1.00			
IRR	-0.13	-0.41*	-0.05	0.07	0.09	0.03	0.27	0.16	1.00		
EMG	0.01	-0.20	0.03	0.02	0.11	0.04	0.32	-0.16	-0.07	1.00	
SA	0.36	0.13	0.20	-0.15	0.26	0.10	0.29	-0.26	-0.12	-0.05	1.00

* $p < .01$

** $p < .05$

Note: The IPAT, APQ and IE are the personality tests used in the study. CBP, CHR and CRR represent the difference between the means of the first five conditioning trials and the last five conditioning trials for blood pressure, heart rate and respiration rate, respectively. IBP, IHR and IRR represent the mean of the first five conditioning trials. SA represents state anxiety.

Correlation Coefficients for the Contingent Group

	IPAT	APQ	IE	CBP	CHR	CRR	IBP	IHR	IRR
IPAT	1.00								
APQ	0.49	1.00							
IE	0.70**	0.50	1.00						
CBP	-0.22	-0.23	0.03	1.00					
CHR	0.13	0.22	0.22	0.22	1.00				
CRR	-0.04	-0.28	-0.50	-0.18	-0.07	1.00			
IBP	0.63*	0.22	0.68**	-0.02	0.20	-0.23	1.00		
IHR	-0.32	-0.33	0.01	-0.03	-0.66**	-0.26	-0.05	1.00	
IRR	-0.10	-0.12	0.11	0.23	0.03	-0.70**	0.25	0.16	1.00

** $p < .01$

* $p < .05$

Note: IPAT, APQ and IE are the personality tests used in the study. CBP, CHR and CRR represent the difference between the means of the first five conditioning trials and the last five conditioning trials for blood pressure, heart rate and respiration rate, respectively. IBP, IHR and IRR represent the mean of the first five conditioning trials.

Correlation Coefficients for the Random Group

	IPAT	APQ	IE	CBP	CHR	CRR	IBP	IHR	IRR
IPAT	1.00								
APQ	0.34	1.00							
IE	-0.03	0.09	1.00						
CBP	-0.01	0.00	-0.06	1.00					
CHR	-0.36	-0.17	-0.24	-0.39	1.00				
CRR	-0.34	-0.48	-0.37	-0.08	0.30	1.00			
IBP	-0.06	-0.25	-0.22	-0.09	0.07	0.14	1.00		
IHR	0.10	-0.14	0.45	0.50	-0.46	0.02	0.00	1.00	
IRR	-0.17	-0.75**	-0.24	-0.19	0.17	0.67**	0.30	0.15	1.00

** $p < .01$

Note: IPAT, APQ and IE are the personality tests used in the study. CBP, CHR and CRR represent the difference between the means of the first five conditioning trials and the last five conditioning trials for blood pressure, heart rate and respiration rate, respectively. IBP, IHR and IRR represent the mean of the first five conditioning trials.